

**824 35MHZ
OSCILLOSCOPE
OPERATION AND SERVICE
MANUAL**

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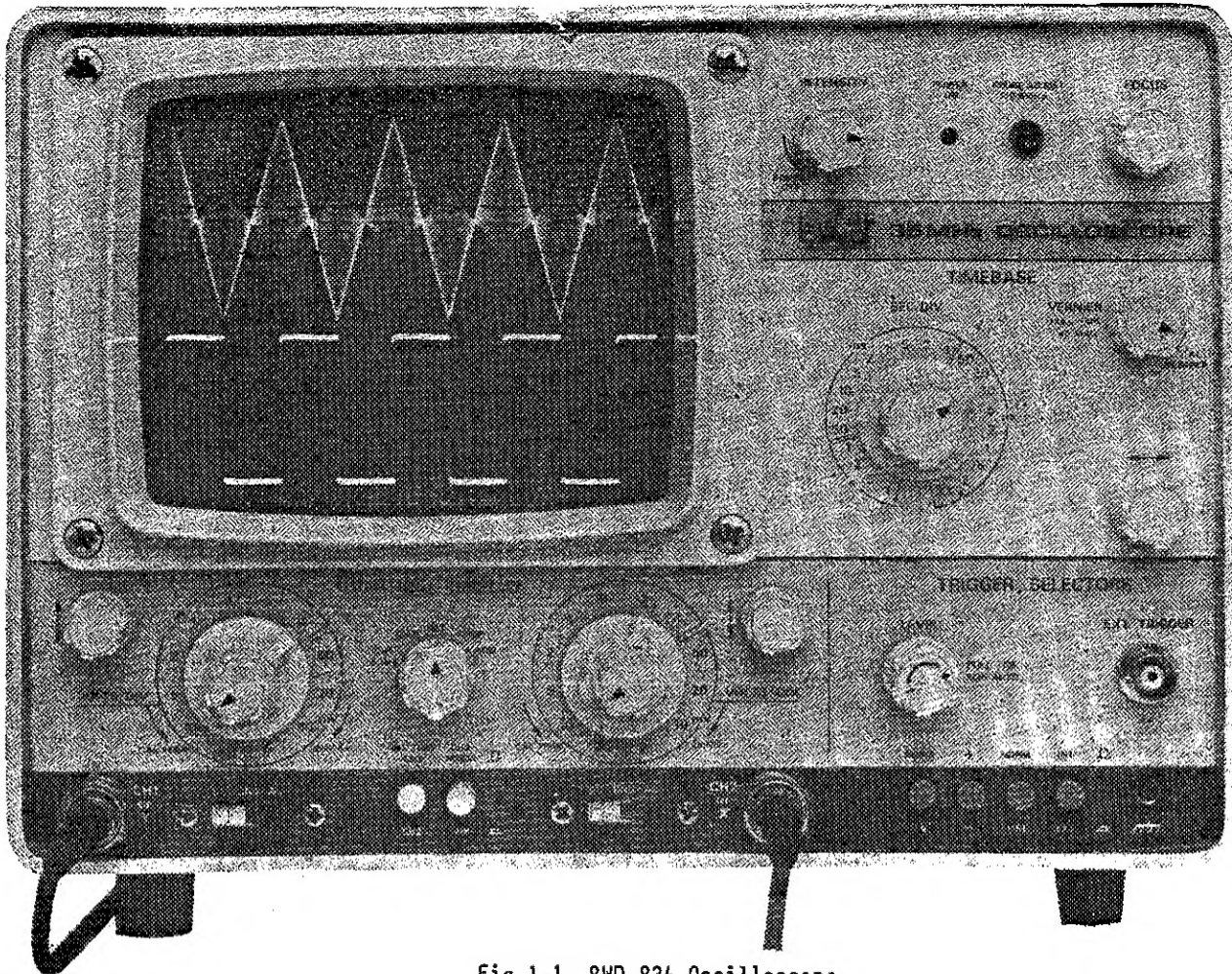


Fig 1-1 BWD 824 Oscilloscope

1.0 INTRODUCTION

The BWD 824 Oscilloscope provides the capability of making precision measurements easily and quickly. It's 35MHz bandwidth, high sensitivity, wide range time base and extremely stable triggering makes it suitable for a broad range of applications in education, servicing or design.

With an amplifier rise time of less than 10nsec fast digital pulses from TTL-HCMOS or similar, circuits can easily be handled, it is suitable for micro processors, small computers, video games and other digital circuits.

In TV applications the sync separator with automatic change over from frame to line lock makes servicing of video recorders, colour TV, VDU's and other video products a simple matter. The 2mV amplifiers can view signals across recording or playback leads enabling measurements to be made from input to output of VCR's etc.

The same features are also ideal for analog and audio applications. Signals developed by the new digital recording techniques are readily accommodated and an identical X-Y facility with low phase shift to above 100kHz can be used in audio and communication measurements.

A wide range of accessories is available to further increase the BWD 824 capabilities. These are listed at the end of Section 2.

SAFETY INFORMATION

1. At certain locations in this Handbook and on the instrument back or front panels will be found statements or symbols calling attention to a safety requirement or feature.

2. Symbols used are as follows:-

DANGER HIGH VOLTAGE

CIRCUIT GROUND

POWER LINE GROUND

CAUTION - Check Handbook to verify maximum input or output.

DANGER To alert of possible danger to either operator or equipment that may be present during the next Handbook procedure.

WARNING To alert operator that damage may occur to equipment under test if certain precautions as detailed, are not followed.

3. Do not use this instrument in an explosive atmosphere.

4. Do not remove the covers unless you are experienced in servicing this class of equipment, lethal voltages are present on several circuits.

5. Instrument Power Source. This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multi-phase system, or across the legs of a single-phase three-wire system.

This instrument can be operated from either a 115 Volt or 230 Volt nominal line voltage source, 48 to 62Hz. This instrument may be damaged if operated with the line voltage connected to incorrect positions for the line voltage applied.

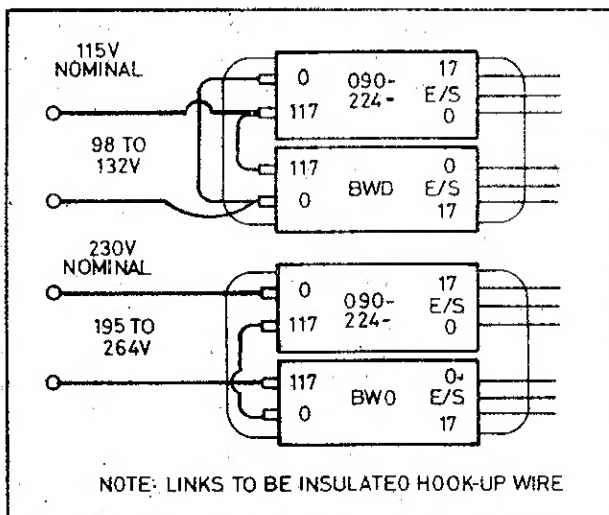


Fig 1-2 Transformer Interconnections

6. NOTE Colour-coding of the cord conductors is as follows:-

Line	Brown
Neutral	Blue
Safety Earth (Ground)	Green/Yellow Stripe

The power transformer is provided with primary tapplings which may be changed by resoldering the links to suit the local power line voltages. The connections are as shown below. Instruments sold in Australia are connected for 195-264V operation. Export instruments have a label attached stating the operating range the transformer has been set to.

7. To avoid the possible hazard of fire or other internal damage, use only the fuse type and rating as specified on the rear panel and listed in the Handbook Parts List.

2.0 PERFORMANCE

2.1 VERTICAL AMPLIFIERS

Display Modes:	CH1, CH2, Alt, Chopped (approx 300kHz), Add.						
Bandwidth:	DC (or 4Hz AC coupled) to 35MHz -3db from 5mV to 20V. Referred to 6 div deflection from a 50ohm terminated source with vernier to Cal.						
	DC to 15MHz -3db at 2mV (vernier clockwise).						
Rise Time:	10nsec over a 6 div deflection 5mV to 20V/div. 23nsec over a 6 div deflection 2mV/div.						
Sensitivity:	2mV to 20V/div, 5mV to 20V direct plus a vernier control with a range approx 2.5:1 which extends input sensitivity to 2mV/div.						
Input R & C:	1Mohm +/-2% paralleled by approx 30pF.						
Maximum Input Voltage:	400V DC + peak AC. 800V p-p at 1kHz or less.						
Calibration Accuracy:	<table border="0"> <tr> <td>5mV to 20V/div +/-3%</td> <td>) +5°C to +40°C</td> </tr> <tr> <td>2mV/div +/-20%</td> <td>) add 2% 0°C to +5°C and</td> </tr> <tr> <td></td> <td>) +40°C to +50°C</td> </tr> </table>	5mV to 20V/div +/-3%) +5°C to +40°C	2mV/div +/-20%) add 2% 0°C to +5°C and) +40°C to +50°C
5mV to 20V/div +/-3%) +5°C to +40°C						
2mV/div +/-20%) add 2% 0°C to +5°C and						
) +40°C to +50°C						
Trace Inversion:	CH2 may be inverted to provide a single channel differential facility in the Add mode.						
CMRR:	At least 20db from DC to 5MHz. Common mode signal < 8 div with one vernier adjusted for optimum rejection.						

2.2 CH2 AS X AMPLIFIER IN X-Y MODE

Bandwidth: DC to 1MHz -3db.
Sensitivity: 2mV to 20V/cm.
Phase Shift: Less than 2° from DC to 100kHz.

2.3 TIME BASE

Range: 0.2 μ sec to 1sec/div, 21 steps in 1, 2, 5 sequence with 2.5:1 vernier which extends range to 2.5 sec/div.

Calibration:

Mag X1	Mag X5
$+5^{\circ}$ to $+40^{\circ}$ 0.2 μ sec to 1 sec/div +/-3%	$+5^{\circ}$ to $+40^{\circ}$ 50nsec to 0.1 sec +/-5% 40nsec over centre 8 div +/-6%
0° to $+5^{\circ}$ & $+40^{\circ}$ to $+50^{\circ}$ 0.2 sec to 0.2 sec/div +/-5% 0.5 & 1 sec/div +5% to -8%	0° to $+5^{\circ}$ & $+40^{\circ}$ to $+50^{\circ}$ 100nsec to 0.02 sec/ div +/-7% 20nsec over centre 8 div +/-7% 0.05 & 0.1 sec/div +8% to -10%

2.4 TRIGGER

Source:	CH1, CH2, external or AC line frequency.
Video:	Frame or line selection with automatic change-over. Frame lock 0.1 sec to 100 μ sec, line lock 50 μ sec/div, and above.
Slope:	Internal, + or - with level select over range of amplitude visible on screen. External, + or - with level select over 4V p-p
Sensitivity:	Internal, 0.4 div 15Hz to 10MHz increasing to 1 div at 5Hz & 40MHz. External, 100mV p-p 15Hz to 10MHz 250mV p-p 1Hz to 40MHz Maximum level select range 4V p-p 40V p-p with 10:1 probe
Ext. Input Impedance:	1MR \pm 5% paralleled by 20pF approx.
Max. Input:	200V DC or DC plus peak AC to 1kHz.
Video Trigger:	2 div. to over 8 div of composite waveform for frame or line lock.

2.6 GENERAL DETAILS

Timebase Gate Output:	+3V falling to 0V during sweep from 4.7kohm source.
Z Modulation:	DC coupled to 10MHz. Input impedance 10kohm. +4V will blank trace at normal intensity. Max. input \pm 30V p-p.
Probe Adjust.:	Output 0.5V p-p approx rectangular positive going with respect to ground, line frequency.
CRT:	Rectangular 8 x 10 div (1 div = 9.5mm). Internal graticule and mesh PDA operating at approx. 6.0KV. Fitted with P31 phosphor and Blue filter.
Trace Rotation:	Rear panel preset enables trace to be aligned with graticule.

2.7 POWER REQUIREMENTS

AC:	98 to 132V and 195 to 264V by internal selection. 48 to 62Hz. 25 Watts max.
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2.8 ENVIRONMENTAL

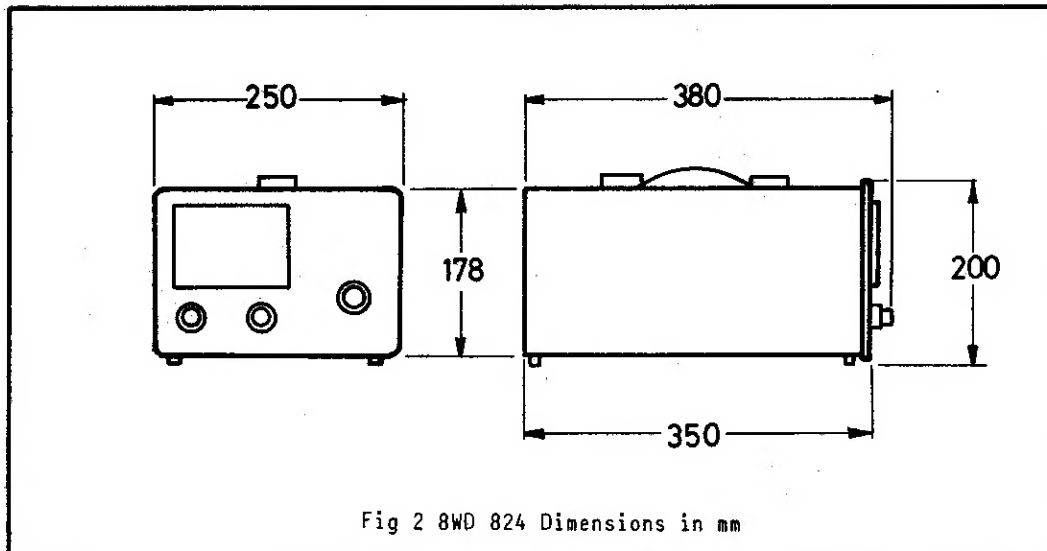
Specification is met less otherwise stated between +5°C to +40°C at a relative humidity of less than 95% and from 0°C to +50°C at a relative humidity of less than 50%.

Weight:	Instrument only:	7.8Kg
Shipping Weight:	Instrument only:	9.1Kg
Ordering Code:	Standard Model:	BWD 824

Instrument supplied complete with 2 x P32 1:1/10:1 probes, power cord and Handbook.

2.9 OPTIONAL ACCESSORIES

1:1 & 10:1 Duo Range Probe	P32	Folding View Hood	H46
100:1 1500V Probe	P37	Protective Front Cover	SC53
Demodulator Probe	P34	Dust Cover	D30
100 AMP DC-1kHz Current Probe	P82	Oscilloscope Trolley	T61
2-2E	Cameras, details on request		



3.1 FUNCTION OF CONTROLS

The following descriptions are to assist an operator to become familiarised with the location, operation and function of the BWD 824 controls and connectors.

VERTICAL AMPLIFIERS SECTION (numbers refer to Fig 3-1 page 3-2)

① and ② CH1 and CH2 Volts/Div Control selects the vertical factor in a 1,2,5 sequence. (Vernier must be in the detent position for the indicated factor). Calibration accuracy is better than 3%.

③ Vernier Provides continuously variable deflection between the calibrated settings of the VOLTS/DIV switches and at max sensitivity increases the sensitivity to approx 2mV/div.

④  Positions the display vertically.

⑤ Inputs Connectors For application of signals to the vertical amplifiers. In the XY mode, signals applied to CH2 input provide the horizontal deflection.

⑥ DC - GND - AC Slide switch selects the input coupling to the vertical amplifiers. In the AC position signals are capacitively coupled to the vertical amplifier so the DC component of the signal is blocked. In the DC position, all components of the input signal are passed to the amplifiers. When switched to GND the input connectors are disconnected from the amplifiers and the attenuator input is grounded.

⑦ Vertical Display Rotary switch selects 5 modes of operation for the amplifier.

CH1 CH1 only displayed.

CH2 CH2 only displayed.

ALT. Dual trace display where the display is switched between channels at the end of each sweep.

CHOP. Dual trace display where the display is switched between channels at a rate of approx 300kHz.

ADD. Signals applied to CH1 and CH2 inputs are algebraically added and displayed as one trace on the CRT. With the CH2 INVERT switch engaged, the display is CH1 minus CH2, i.e. differential operation when both VOLTS/DIV are at identical settings.

- ⑧ INT TRIGGER, CH1 or CH2 Push button to select source of internal trigger.
- ⑨ CH2 NORM-INV Push button. Trace is displayed normally when push button is out and inverted when in.

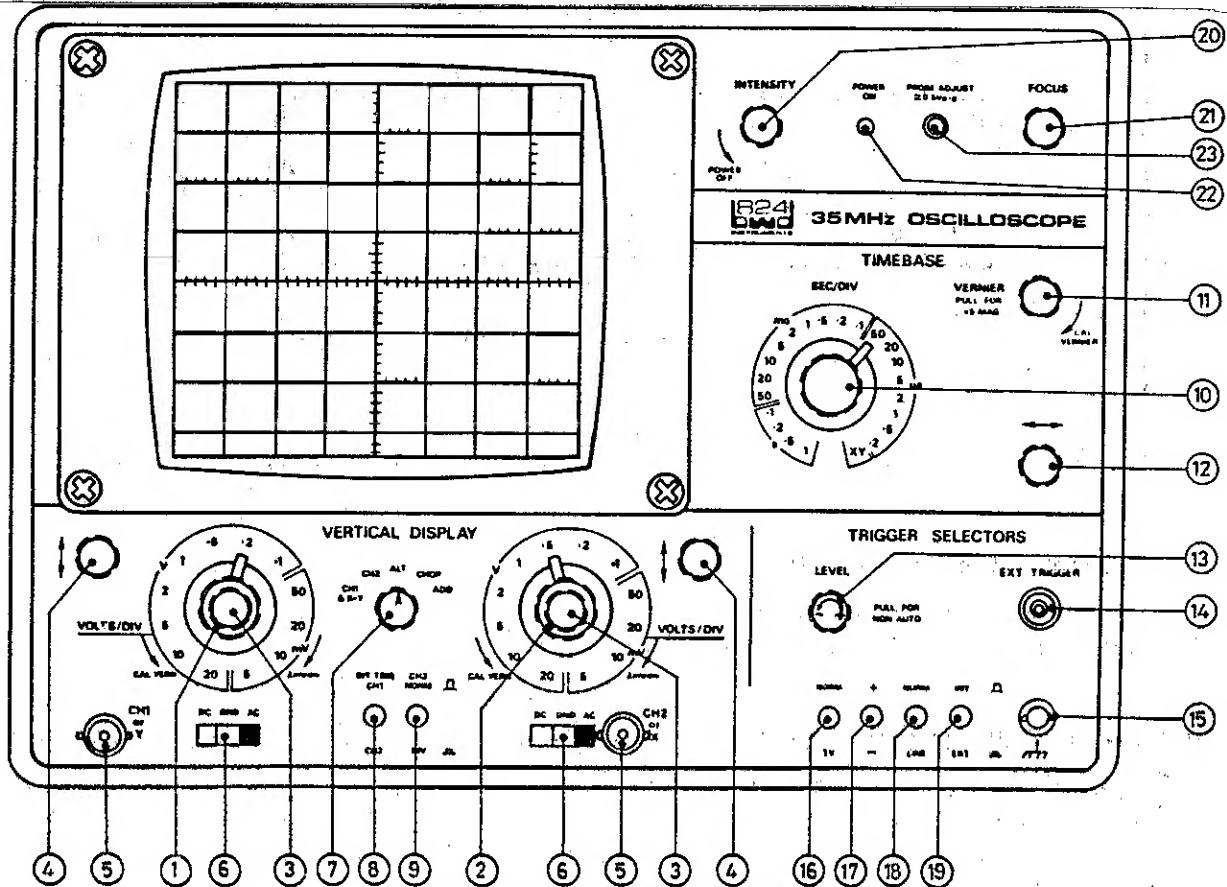


Fig 3-1 Front Panel Controls

3.2 TIME BASE SECTION

⑩ **SEC/DIV** Time base range switch controls the sweep time from $0.2\mu\text{sec}$ to 1 SEC/DIV in 21 steps. Turned fully clockwise, it switches off the time base and connects CH2 vertical amplifier to provide the X display for XY operation with a sensitivity from 2mV to 20V/div. When the vernier is at CAL the calibration is $\pm 3\%$ over the entire range. Another function performed by the switch is to change over the video sync separator from frame selection to line selection at sweep speeds of $50\mu\text{sec}/\text{div}$ and above.

⑪ **Vernier Control & x5 MAG** When the control is rotated counter clockwise, it reduces the time base speed by at least 2.5 times.

When the knob is pulled out, the sweep speed is increased by x5.

⑫ **Horizontal Control** Control positions the trace horizontally on the screen.

⑬ **Level:** Selects the precise point on the triggering waveform that initiates the time base. Selection is available over 8 div deflection, or up to 4V p-p external. When the level knob is pushed in, the time base will free run if a trigger signal is not present, or if the control is turned out of the range of the signal.

With the knob out, the automatic base line is eliminated and no trace is present in the absence of a trigger signal.

⑭ **EXT TRIGGER** input socket for application of signals to provide external trigger.

⑮ **4mm socket** for Ext connection to chassis.

3.3 PUSH BUTTON SWITCHES

①⑥ **NORM/TV**, out position is normal trigger; in position selects the video sync separator. When the time base is switched between 0.1 sec and 0.1msec/div, the sync separator supplies frame pulses to trigger the time base. From 50µsec and above, the TV line will trigger the time base.

①⑦ **+/-** Out position enables the positive or rising slope of the trigger waveform to initiate the time base. With the button in, the negative or falling slope triggers the time base.

①⑧ **AC Line** Out is normal operation, in selects the line frequency powering the Oscilloscope to trigger the trace. Phase of the trigger point is adjustable by the LEVEL control and the +/- switch.

①⑨ **INT/EXT** Out position connects the internal trigger signals as selected by the trigger source button in the vertical amplifier section. In position selects signals from the EXT TRIGGER BNC socket.

3.4 CRT CONTROLS

②⑩ **Intensity** Fully counter clock this control switches off the Oscilloscope. When turned clockwise, the Oscilloscope is switched on and rotation clockwise increases the trace intensity.

②⑪ **Focus** Adjusts the CRT focus at any setting of the intensity control. Adjustment is made in conjunction with the rear panel astigmatism preset control to obtain the optimum trace sharpness.

3.5 GENERAL FEATURES

②② **LED Power Indicator** Illuminates when the Intensity control is turned on.

②③ **Probe Adjust** 0.5V p-p Approx, Line Frequency rectangular positive going waveform.

3.6 REAR PANEL FACILITIES

① **Astigmatism Preset** used in conjunction with the front panel focus control to adjust the trace sharpness. Will rarely need adjustment once correctly set.

② **Trace Rotate** Preset control enables the CRT trace to be aligned with the internal graticule.

③ **T.B. Gate** Time base blanking waveform. 0V during sweep. +5V during blanking, 4k7 source impedance.

④ **Z MOD** Input socket for intensity modulating the CRT. Maximum input is +/-30V and input impedance is 10kohm. Modulation requires a positive input of +4V to blank trace at normal intensity.

⑤ **AC Line Fuse** Fuse size and value is shown in Parts List and must be adhered to for maximum instrument safety.

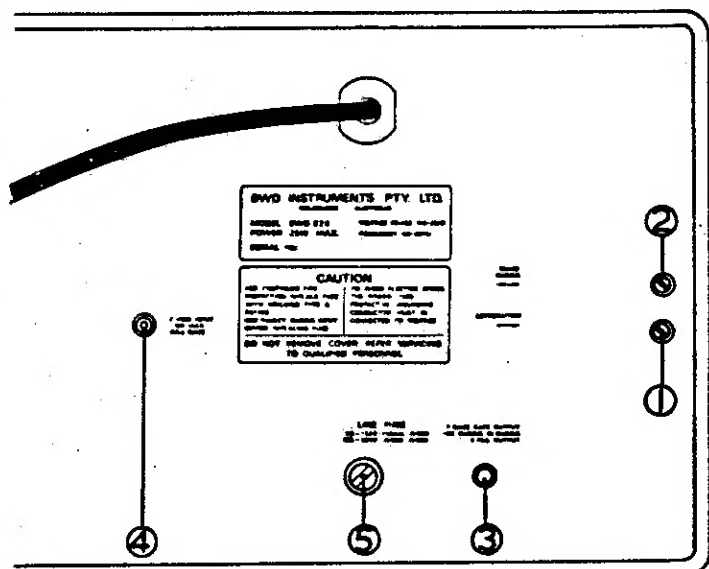


Fig 3-2 Rear Panel

I N S T R U M E N T F A M I L I A R I S A T I O N

4.1 One of the major features of the BWD 824 Oscilloscope is that normal operation is obtained when all controls are in their normal position, i.e. when all push buttons are OUT and all controls are pushed in. A quick scan over the panel therefore immediately indicates any variations from normal and assists in quick familiarisation of the instrument's operation.

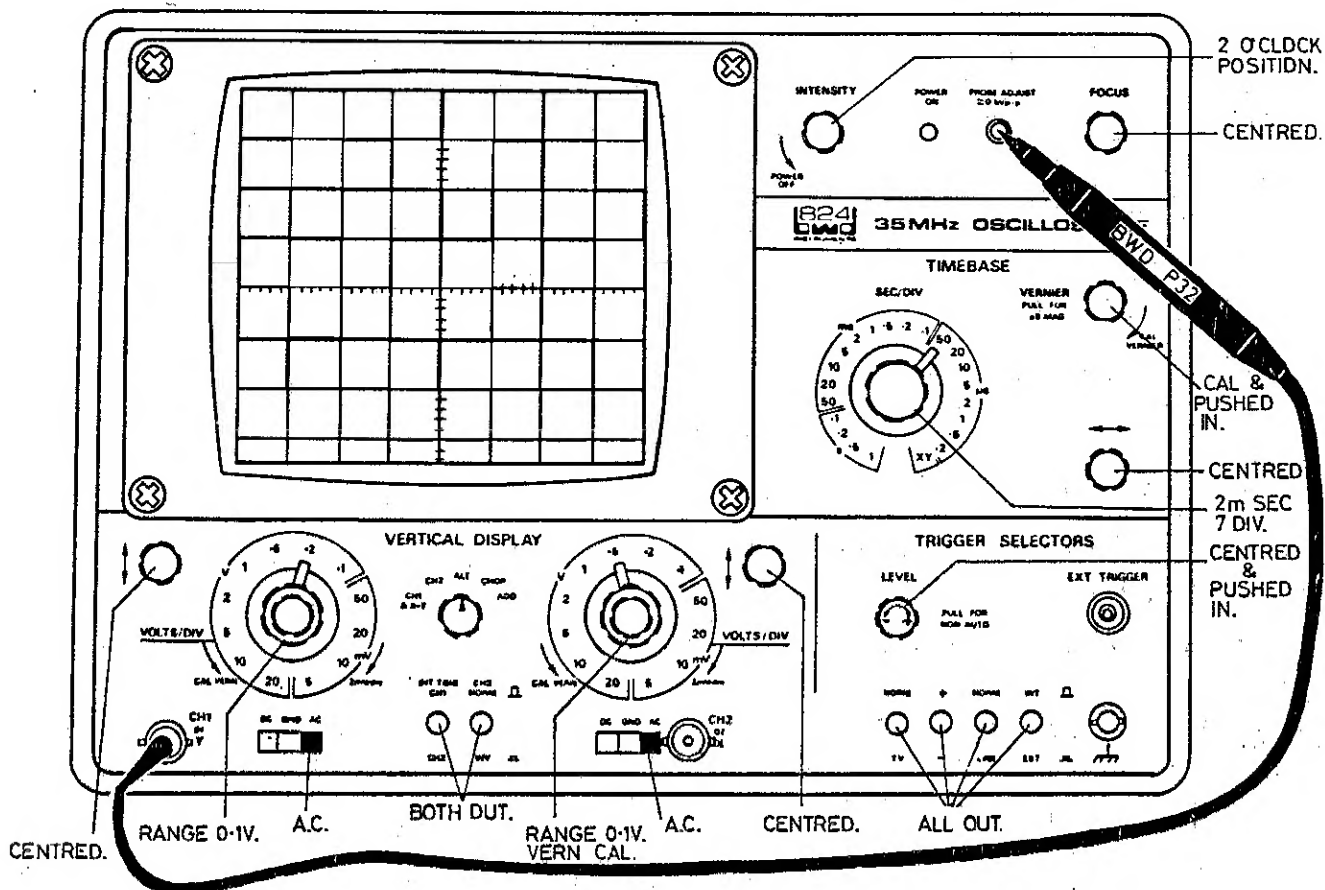


Fig 4-1

VERTICAL AMPLIFIERS

4.2 For first time operation, if you are unfamiliar with an Oscilloscope, set the controls as above and follow the steps outlined until each feature is understood.

4.3 Apply power to the Oscilloscope, switch on and turn the Intensity Control to approx 2 o'clock position. Within 15 seconds a trace will appear. Adjust intensity, focus and position to set trace centrally across screen. If trace is not aligned with the graticule, adjust the Trace Rotation preset on the rear panel to align it.

Now connect a BWD P32 Probe to CH1 input and set it to 1:1. Touch the Probe tip to the 0.5V CAL waveform output socket.

A rectangular wave will be displayed 5 div high and one waveform per 5 divisions horizontally. Slide the CH1 input switch to DC, the trace will rise and the bottom of the waveform will now correspond with the CRT centreline indicating the input signal is a waveform positive going with respect to ground. Slide the input switch to GND, the square wave will be removed and replaced by a bright reference base line as the Auto time base operates. The GND switch disconnects the input signal in this condition, but grounds the amplifier. Slide the switch back to DC and the waveform will again be standing on the centreline.

4.4 DUAL TRACE OPERATION

Set CH2 amplifier as for CH1, then turn the Vertical Display to CH2, then press the INT TRIG button to select CH2. Take a parallel signal from the calibrator output, (or a similar waveform) to CH2 input leaving CH1 signal connected.

ALT

Reduce attenuator settings of both amplifiers to 0.2V/div then switch VERTICAL DISPLAY to ALT. Two traces will appear which can be positioned above and below CRT centreline with their respective controls.

With the traces positioned above each other, turn the time base range switch to slower sweep speeds and observe how flicker between the traces increases, until at 10msec/div the switching between the traces is readily visible. This is the useful lower limit of the ALTERNATE switching mode. Now increase the time base speed, the traces will remain locked right through to 0.2µsec/div.

CHOP

Return time base range to 10msec/div again and switch the VERTICAL DISPLAY to CHOP. Trace flicker immediately stops. When the time base frequency is reduced, the two traces appear simultaneously down to the lowest sweep frequency.

Increase time base speed and note that at speeds above 50µsec/div the waveforms will start to show the individual chopping sections indicating the useful upper limit of CHOP displays.

As has been shown, a wide overlap exists where both forms of dual trace display can be used satisfactorily.

ADD

Apply a 1V p-p 1kHz sine wave to CH1 and CH2 inputs. Set the time base to .5msec/div and both attenuators to .5V/div so that the waveform on each trace is 2 div high. Turn the Vertical Display switch to ADD.

A single trace will appear with a 4 div display, i.e. the two traces have been **added** together. Now press CH2 NORM/INV button; the waveform will disappear leaving only a line. This is the **difference** between the two signals or the result when one is subtracted from the other. Applications for this form of measurement are described later. Return Vertical Display switch to CH1 and the NORM/INV switch to NORM.

4.5 TIME BASE

Increase sine wave input to CH1 to present a 6 div high display and select CH1 trigger.

4.6 TRIGGER LEVEL

With the Level knob pushed in, turn the control and observe that the trigger point moves up or down the waveform. When it reaches the top or bottom of the waveform the trace blanks out for a fraction of a second when trigger is lost, then the trace free runs in the Auto condition until the level control is readjusted to select a trigger signal. Now push in the +/- button to select -ve trigger. The waveform will now trigger on a -ve going slope. Clockwise rotation of the LEVEL control will increase the trigger point towards the positive point of the waveform, anti-clock rotation towards the negative point.

Revert to +ve trigger selection, then pull out the LEVEL knob to normal or NON-AUTO operation. When the LEVEL control is now turned, the trace disappears when the trigger point extends past the waveform limits.

The 824 trigger level control has a variable sensitivity providing a fine control in the centre of its range, enabling signals below 4mm amplitude to be reliably locked at frequencies up to 10MHz.

4.7 T.B. VERNIER

Turn Vernier anticlockwise - observe the number of waveforms on the CRT increases by at least x2.5 times when fully counter clockwise. Return control to CAL.

4.8 MAGNIFICATION

Adjust input frequency to produce one wave per div and locate the peak of each waveform on a vertical graticule line. Pull out the vernier control for x5 magnification.

The trace will expand either side of the centre and any portion of it can be viewed by rotating the position control. Return the VERNIER control to x1 and recentre trace horizontally with the position control.

4.9 HORIZONTAL AMPLIFIER

Identical **XY**

Parallel a 2kHz input sine wave to CH1 and CH2, adjust both for a 6 div display, turn the time base range switch to **XY** and pull out the x5 mag knob. CH1 will now present the vertical display and CH2 the horizontal. To position the display horizontally use the horizontal position control.

Vernier control between attenuator steps is available for both the vertical and horizontal axis. For zero phase shift between **XY** inputs at low frequencies it is essential to use DC coupling on both channels.

4.10 MODULATION

Reset all push buttons to 'out', connect 5V p-p sine wave to CH1, switch attenuator to 1V/div. Set VERTICAL DISPLAY to ALT. Position displays one above the other. Now parallel the 5V signal into rear panel Z Mod socket. The tops of each displayed sine wave will diminish in intensity and the CH2 trace will be broken into a series of light and dark sections.

NOTE: A positive going signal decreases the trace brightness. A negative signal increases intensity. As the input impedance is only 10kohm the signal source should be a low impedance to provide the sensitivity specified. Maximum input must be limited to +/-30V.

A P P L I C A T I O N S

5.1 Once the basic operation of the instrument is understood, it can be applied to waveform measurement. As the BWD P32 Probes supplied with the Oscilloscope are likely to be widely used to conduct the signal from the product under observation to the Oscilloscope amplifiers, it is essential that they be correctly adjusted before making connection with them.

5.2 PROBE COMPENSATION

The BWD P32 Probe has both an x1 and x10 divider ratio. No compensation is provided in the x1 position as no signal division takes place. Incorrect adjustment in the x10 position can cause measurement errors at all frequencies above 100Hz. Check the probe regularly to ensure it remains correctly adjusted.

Adjust probe as follows:-

1. Connect P32 probes to CH1 & CH2 inputs. Select x10 on probe bodies.
2. Set both VOLTS/DIV switches to 10mV and DC-GND-AC switches to DC.

Set VERTICAL DISPLAY to CH1 and insert tip of CH1 probe into PROBE ADJUST socket.

4. Set the time base to display 4 or 5 cycles of the signal and center the display.

5. Adjust the probe compensation if necessary, to produce a flat top waveform, using the small screwdriver supplied with the probe.

6. Repeat process for CH2 probe. For further details of the BWD P32 probe characteristics, refer to the leaflet supplied with the probe.

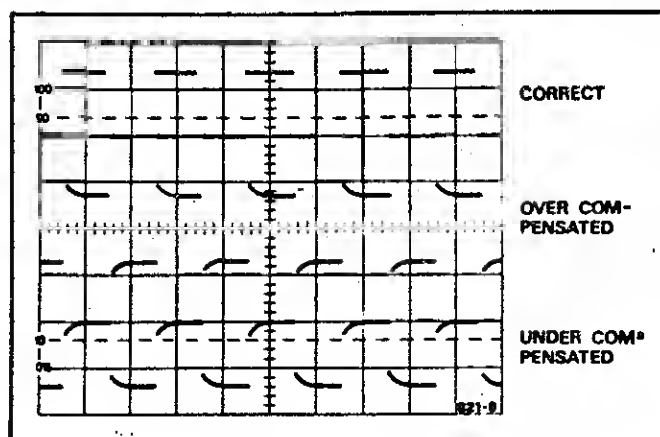


Fig 5-1

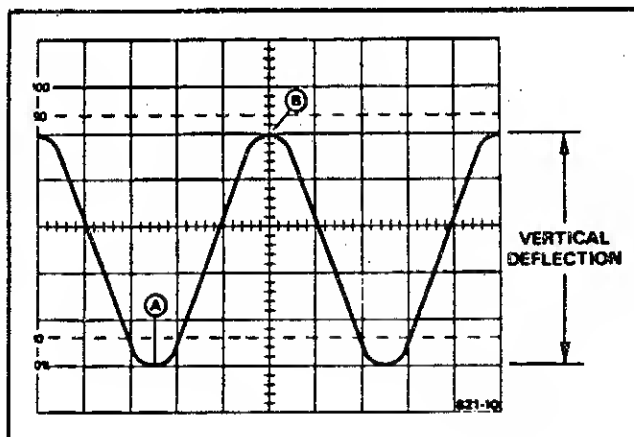


Fig 5-2

5.3 VOLTAGE MEASUREMENT, AC

To measure the peak to peak voltage of the waveform shown in Fig.5-2 proceed as follows:-

a. Connect the signal to be measured to the CH1 input connector.

b. Set the VERTICAL DISPLAY to CH1, and the DC-GND-AC to AC. Then adjust the VOLTS/DIV switch to present the largest waveform within the graticule limits and the time base and trigger for a suitable display. Ensure the VOLTS/DIV VERNIER controls are fully clockwise in the CAL position.

c. Use the vertical and horizontal position controls to align the bottom edge of the waveforms with a horizontal graticule line and the top of one of the waveforms in line with the vertical graticule centreline.

d. Measure the vertical distance between points A & B and multiply by the setting of the VOLTS/DIV control.

If a probe is used, multiply the value obtained by the attenuation ratio, i.e. Volts peak to peak = Vertical deflection x VOLTS/DIV x probe attenuation ratio.

NOTE: If the amplitude measurement is critical, or if the trace is thick (as a result of hum or noise on the signal), a more accurate value can be obtained by measuring from the top of a peak to the top of a valley. This will eliminate trace thickness from the measurement.

Engage the 20MHz Bandwidth Limit switch to sharpen the trace by removing very high frequency noise, if frequency is below 5MHz.

e. Example

The Vertical deflection of the waveform in Fig.S-2 is 5 div. If the VOLTS/DIV is set to 0.5V and the probe is x10, then the result is:-

$$5 \text{ (div)} \times 0.5 \text{ (V/DIV)} \times 10 = 25\text{V p-p}$$

5.4 VOLTAGE MEASUREMENT, rms

a. If the waveform measured in Fig.S-2 is sinusoidal, its r.m.s. value can easily be calculated by the following formula.

$$\text{Volts rms} = \frac{\text{Volts p-p}}{2\sqrt{2}}$$

From the previous example:-

$$\text{Volts rms} = \frac{25}{2\sqrt{2}} = \frac{25}{2.818} = 8.84\text{Vrms}$$

5.5 VOLTAGE MEASUREMENT, DC

To measure DC waveforms shown in Fig.5-3, proceed as follows:-

a. Connect the signal to be measured to the CH1 input connector.

b. Set the VERTICAL DISPLAY to ALT and the DC-GND-AC to DC. Then adjust the VOLTS/DIV switch to present the largest waveform within the graticule limits.

Time base and trigger should be adjusted for a suitable display. Ensure the VOLTS/DIV VERNIER is in the CAL position.

c. Set the DC-GND-AC switch to GND to establish how the waveform is related to ground. Move the CH1 trace until it corresponds with the nearest graticule line. Now superimpose CH2 trace on CH1 to provide a reminder of the ground reference level.

d. Return CH1 DC-GND-AC switch to DC. Do not move either vertical position control. However, if the waveform is now partly off the screen, reduce the signal amplitude by the VOLTS/DIV switch. This will not affect the ground reference levels already determined.

e. Use the horizontal position control to bring the portion of the waveform to be measured to the centre graticule line.

f. Measure the vertical distance from the ground reference graticule line to the point to be measured.

g. Multiply the Vertical Deflection above or below the ground reference as required by the VOLTS/DIV setting and the probe attenuation ratio.

Example

The +ve Vertical deflection of the waveform in Fig.5-3 is 3.8 divisions. If the VOLTS/DIV is set to 2 and the probe is x1, then the result is:-

$$+3.8 \times 2 \times 1 = +7.6V$$

The negative deflection is 2 div, therefore the voltage deflection below ground is:-

$$-2 \times 2 \times 1 = -4V$$

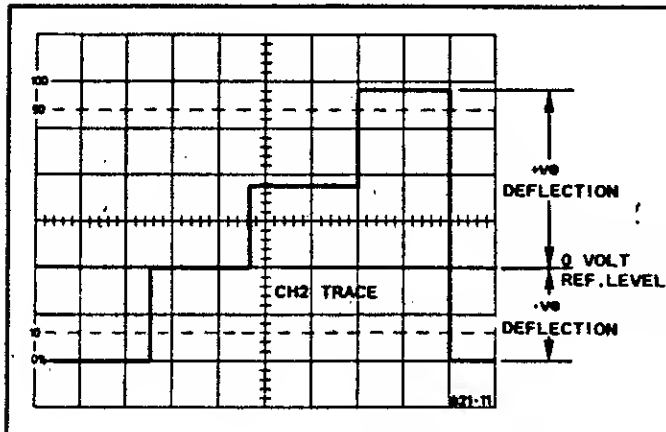


Fig 5-3

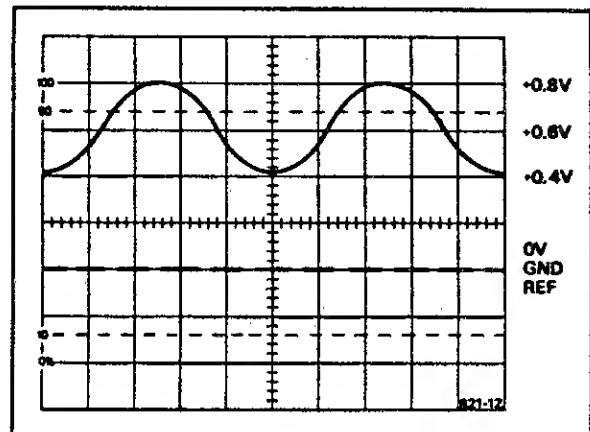


Fig 5-4

5.6 VOLTAGE MEASUREMENT, DC + AC p-p

To measure both AC and DC components of a signal, move the input switch to GND. If the waveform is positive to ground, set the trace on the bottom graticule line. Return the switch to DC and adjust the VOLTS/DIV switch for the maximum amplitude display. Measure the AC p-p voltage as described under 5.3 and the DC component between the required levels as described under 5.5.

Example

With the attenuator set to 0.2 Volts/Div and the input probe switched to X1 the:-

AC component = 0.4V p-p and the

DC component (to centre of AC waveform) = 0.6V

Note: When the DC component is much greater than the AC component, the AC may be too small to measure. In this case, measure the AC and DC components separately.

5.7 VOLTAGE MEASUREMENT, ELIMINATION OF COMMON MODE SIGNALS

a. By combining the use of the VERTICAL DISPLAY ADD with the CH2 NORM/INV facilities undesired signals on which the desired signal is riding can be removed.

b. Apply the signal containing both the desired and undesired signals to CH1 input connector.

c. Apply the undesired signal to CH2 input connector.

d. Set the VERTICAL DISPLAY to ADD and the NORM/INV switch to INV.

e. Set both VOLTS/DIV switches to the same sensitivity. The display should now show the desired signal. If some residual is still present, use the CH2 VOLTS/DIV switch and VERNIER control to reduce it to the lowest level.

f. Waveform measurement of the required signal can be made as described in para 5.3.

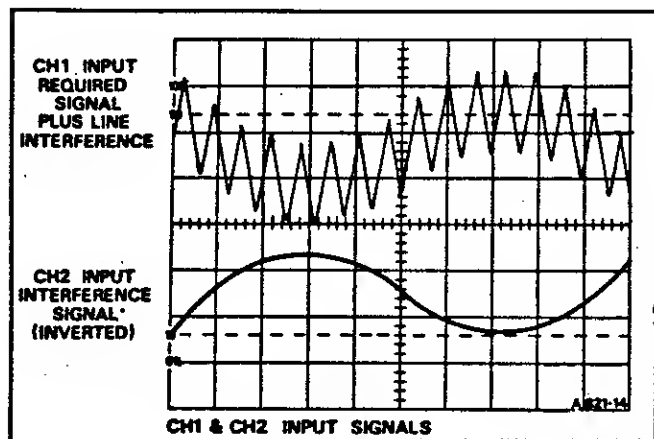


Fig 5-5A

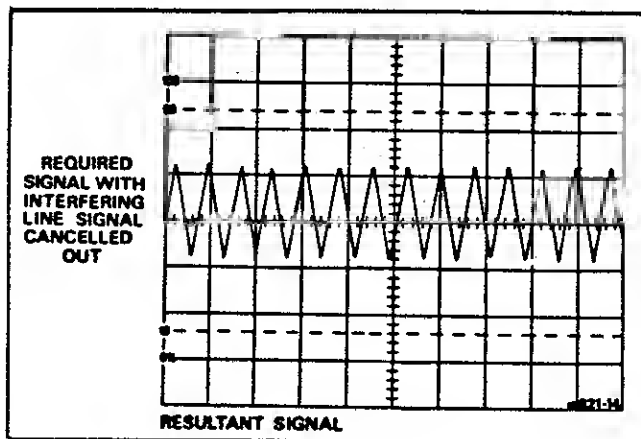


Fig 5-5B

5.8 CURRENT MEASUREMENT, AC & DC

Although a voltage signal is the only phenomena that can be observed on an oscilloscope directly, it is possible to convert other phenomena into voltage and so obtain another measurement.

Current can be measured in two ways:-

By measuring the voltage developed across a resistor which is converted to current using Ohms law, or:-

By using a current probe, such as the BWD P82.

1. Current Through a Known Resistance

If one end of the resistor is at ground potential, connect a P32 probe to the active end and measure the AC and/or DC voltage developed across it, as described in para's 5.3 and 5.5.

a. Example

If the DC voltage across a 10ohm resistor is measured as 0.23V then the current flowing is found from $I = \frac{E}{R}$

$$I = \frac{0.23}{10} \text{ Amps or } \frac{0.23 \times 1000}{10} \text{ mA} = 23\text{ma}$$

AC p-p current is measured the same way and converted to rms values if sinusoidal as in para 5.4.

b. If the circuit resistor is not grounded at one end, the voltage drop across it can be measured differentially as described in para 5.7, by connecting CH1 probe to one end, CH2 to the other and then setting both probes to x1 or x10 as required, both CH1 & CH2 attenuators to the same VOLTS/DIV to bring the trace on the screen and both DC-GND-AC switches to AC or DC as required and CH2 NORM/INV switch to INV.

c. If DC measurements are made, ensure the DC to ground voltage present on the component does not exceed x8 the attenuator setting or the measurement will be accurate.

d. Differential measurements across the component are made in exactly the same way as normal AC or DC measurements described under 5.3 & 5.5, i.e.:-

$$\text{vertical deflection} \times \text{Volts/Div} \times \frac{\text{Probe Attenuation}}{\text{Factor}}$$

and then converted to current as described under 5.8a.

2. BWD P82 Current Probe

In high current circuits where a wire is available to clamp a probe around a P82 probe enables current waveforms from DC to over 1kHz and at levels to 100 Amps to be measured. The probe cable is plugged into one vertical channel, the attenuator set to 1V/div and the resulting waveform is converted to current by the following formula:-

$$I \text{ amps} = \frac{\text{vertical deflection}}{\text{deflection}} \times 10 \text{ or } \times 100 \quad \begin{matrix} \text{(depending on} \\ \text{range selected on} \\ \text{P82 probe)} \end{matrix}$$

Example: If vertical deflection is 6 div and P82 range is x10:-

$$I = 6 \times 10 = 60 \text{ Amps}$$

5.9 TIME MEASUREMENT

a. To measure the time of each cycle of the waveform shown in Fig 5-6 set the oscilloscope up as follows.

b. Connect the signal to be measured to CH1 input connector. Set the VERTICAL DISPLAY to CH1.

c. Adjust the trace vertically to set the part of the waveform to be used as the reference to cross the graticule horizontal centreline.

d. Adjust the time base to expand the waveform as wide as possible to obtain the most accurate measurement. Ensure the SEC/DIV VERNIER control is in CAL.

e. Measure the Horizontal deflection where the waveform cuts the centre graticule line. Multiply this by the TIME/DIV setting and by x10 Mag if this control is switched into operation.

f. **Example**

$$\text{Time} = \text{Horiz Defl} \times \text{SEC/DIV} \times \text{MAG}$$

For the waveform shown in Fig 5-6 the Horz Defl = 6.1 div, assume the SEC/DIV is 2msec and magnifier to x1

$$\text{Time} = 6.1 \times 2 \times 1 = 12.2\text{msec}$$

5.10 FREQUENCY MEASUREMENT

a. The frequency of a repetitive waveform is made by measuring the period of one cycle of the waveform and taking the reciprocal of it.

b. Example

Using the waveform in Fig 5-6 and the example on 5.9f. which determined a period of 12.2msec

$$\text{Frequency} = \frac{1}{\text{period}} = \frac{1 \times 10^3}{12.2} = 82\text{Hz}$$

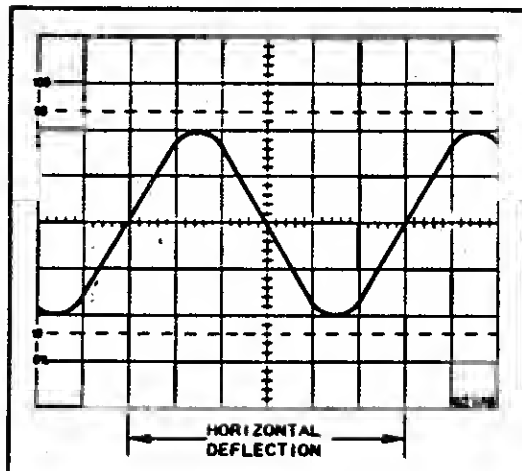


Fig 5-6

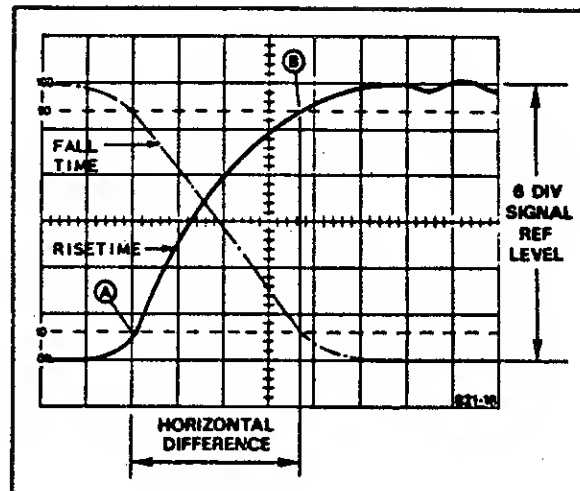


Fig 5-7

5.11 RISE & FALL TIME MEASUREMENT

a. Rise or fall time measurement follow the same procedure as Time measurements, but use the 0, 10, 90 and 100% calibration lines on the graticule. Use the following procedure to make the measurement.

b. Apply the signal to CH1 input and set the VERTICAL DISPLAY to CH1.

Use the VOLTS/DIV and the VERNIER control to set the waveform peak to peak height to correspond to the 0 and 100% graticule lines.

Ensure the A SEC/DIV VERNIER is in the CAL position.

c. Move with the horizontal position control, the point on the waveform corresponding to the 10% line until it also corresponds with vertical graticule line.

Measure the horizontal difference between the 10% and 90% points on the waveform.

d. Multiply this by the SEC/DIV and by the horizontal magnification.

Example

e. The waveform in Fig 5-7 has a Horizontal difference of 3.7 div. If the SEC/DIV was 4μsec and magnification was x1

$$\text{Rise Time} = \text{Horiz difference} \times \text{SEC/DIV} \times \text{Mag.}$$

$$\text{Rise Time} = 3.7 \times 4\mu \times 1 = 14.8\mu\text{s}$$

f. Fall time is measured in the same manner, excepting the 90% fall point is aligned with a vertical graticule mark as shown by the dotted line in Fig 5-7.

5.12 TIME DIFFERENCE MEASUREMENT

a. Time difference between two pulses on waveforms that are synchronised to each other, but one is delayed in time.

b. Apply the two signals to CH1 & 2. Set the VERTICAL DISPLAY to ALT or CHOP depending on the pulse repetition rate.

c. Set the VOLTS/DIV switches for a suitable display amplitude and the SEC/DIV to separate the two pulses to the greatest degree possible within the screen limits.

d. Measure the horizontal difference between the two signals, multiply by SEC/DIV setting and horizontal magnification.

e. Example

The waveform in Fig 5-8 shows a horizontal difference of 3.5 div and assuming the SEC/DIV range is $0.5\mu\text{sec}$ and the magnification is $\times 1$, the time between the pulses is:-

Time = Horizontal difference \times SEC/DIV \times magnification

Time = $3.5 \times 0.5\mu \times 1 = 1.75\mu\text{sec}$

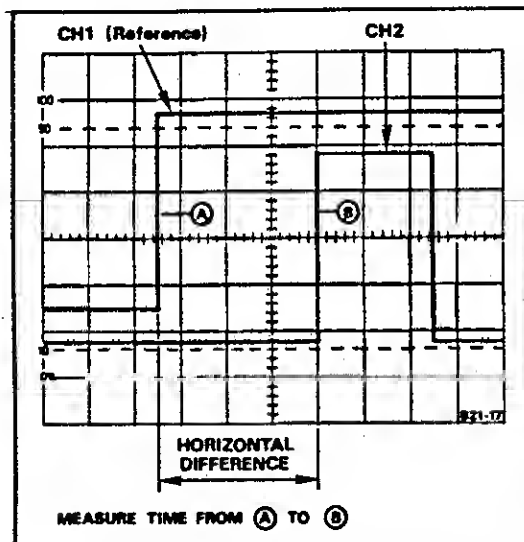


Fig 5-8

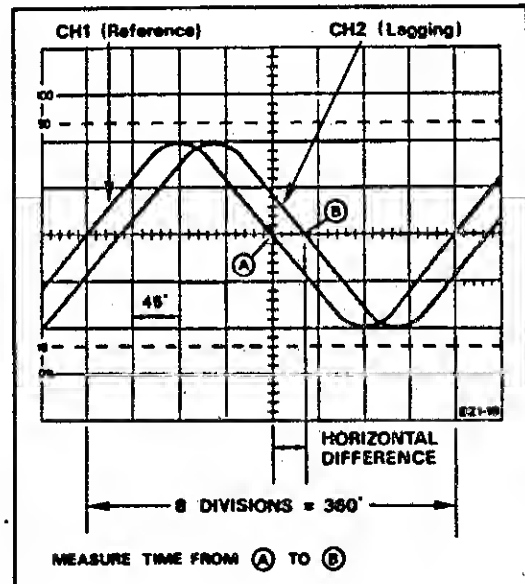


Fig 5-9

5.13 PHASE MEASUREMENT

a. Two methods of measuring phase are described. The first is for relatively large phase angles over the oscilloscope's entire vertical bandwidth. The second method is for precise measurements of small phase angles over a DC to 300kHz frequency band.

5.14 PHASE DIFFERENCE MEASUREMENT

a. Apply the two signals to CH1 and CH2 inputs. Select ALT or CHOP VERTICAL DISPLAY as necessary for the waveform frequency.

c. Adjust the VOLTS/DIV switches for the largest display that can be accommodated, making each signal approx equal in amplitude. Select the reference waveform as the trigger channel and adjust the trigger LEVEL control until the reference waveform is triggered at a point just below the graticule centreline.

NOTE: If one waveform is inverted to the other, press the CH2 INV button.

c. With the SEC/DIV switch and its VERNIER control, adjust the display so that one cycle of the signal occupies 9 divisions of horizontal display.

One division now equals 40° and each sub-division is 8° .

d. Ensure that each waveform is centred vertically on the graticule, then measure the horizontal distance between the rising portion of the waveforms.

e. Example

The waveforms in Fig 5-9 have a difference of 0.8 divisions, therefore the
 Phase Difference = Horizontal difference $\times 40^\circ$
 Phase angle = $0.8 \times 40 = 32^\circ$

f. To obtain a higher resolution if the phase angle is less than 8° , the display can be magnified $\times 10$ after setting up as in 5.14c. Each division is now expanded to 4° and each sub-division to 0.8° .

Fig 5-10 below shows the result when the waveform is positioned centrally on the CRT.

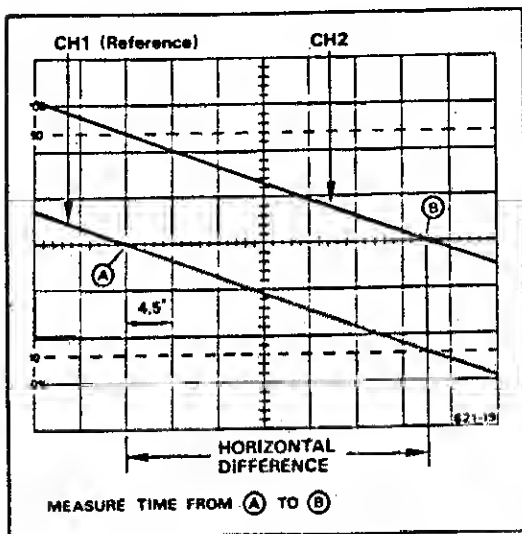
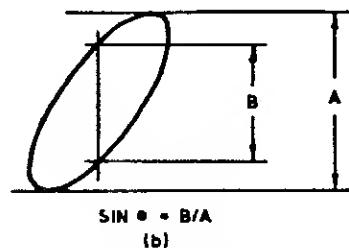
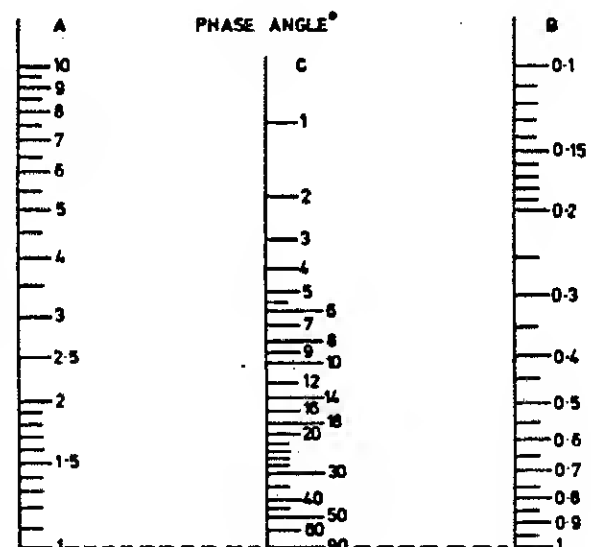


Fig 5-10

Measurement of Phase:



A method of measuring the phase angle between two equal frequency sine waves is to apply one signal to channel 1 and the second input to channel 2 (switched through to X display) in the X-Y mode. The phase difference is obtained from the dimensions of the resulting ellipse shown above. The phase angle may be read from the scales above by joining the appropriate points on scales A & B and reading the phase angle on scale C. For a phase accuracy of $> 2\%$ measurement frequency should be below 100kHz.

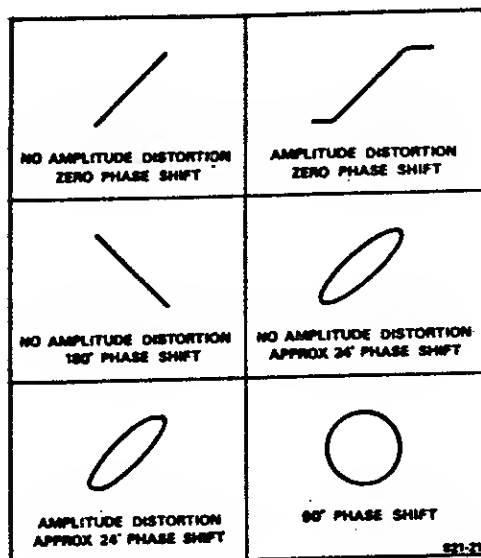


Fig 5-12

Fig 5-11

5.15 X-Y PHASE MEASUREMENT

a. Connect the reference sine wave to CH1 input and the signal to be checked to CH2.

b. Adjust the levels for 6 div amplitude with the VOLTS/DIV switches and VERNIER controls.

If low frequencies are to be checked, set the DC-GND-AC switches to DC. If this is not possible, due to an offset voltage on one input, set both switches to AC. However, phase shift may now occur below 10kHz, due to possible variation in the input coupling capacitors.

c. Switch VERTICAL DISPLAY to CH1 & X-Y and the HORIZ DISPLAY to X-Y. Also switch the TRIGGER SELECTOR to EXT and the LEVEL control to NORM.

d. If no phase shift is present, a straight diagonal line will appear. If phase shift is present, the line will widen out to an ellipse.

e. Phase shift between the two waveforms can be obtained from the chart in Fig 5-11. Max usable frequency range for this method of measurement is DC to 300kHz.

f. Typical displays are shown in Fig 5-12 including the effect of waveform distortion.

5.16 VIDEO (TV) DISPLAYS

The time base and trigger facilities are extremely versatile for video measurements. Displays from a single frame to selected lines from alternate frames may be presented in the dual trace display.

a. Apply the video waveform to CH1 and adjust the attenuator for a 3 to 4 div display. Press the TV button and if the sync signal is positive going, select the + trigger polarity button. If sync is negative going, select - polarity.

b. With the A VOLTS/DIV to 2msec adjust the Level control for a stable lock of the frame video signal.

If the time base is turned towards 50 μ sec the trace will remain locked, but will change over from displaying the frame signal to the line signal.

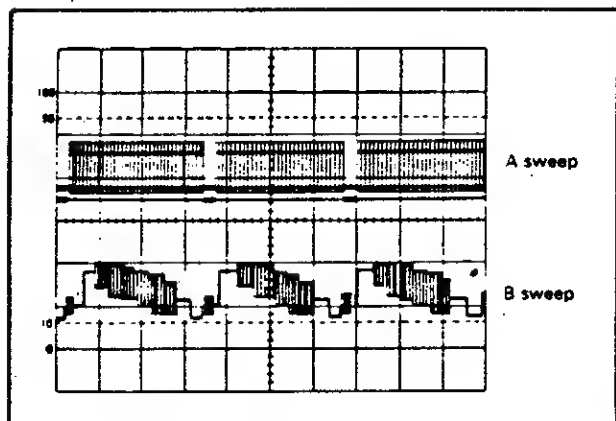


Fig.5-13

To look at lines carrying Tele Text information increase the time base speed to 100 μ Sec/div. Now pull out the time base vernier knob to engage MIX-MAX. Adjust the control to magnify the required lines.

Alternate frames can be displayed in the ALT dual trace mode by increasing the time base speed to 1msec/div or faster to display only the first part of the frame signal. It will then automatically display alternate frame signals and when lines are selected in the MIX-MAG mode they will be from alternate frames.

6. CIRCUIT DESCRIPTION

The circuit description is divided into the following sections:-

6.1 -6.5	Attenuators & Vertical Amplifiers
6.6 -6.14	Trigger & Timebase
6.15	Horizontal Amplifier
6.16-6.17	Power Supplies
6.18-6.19	CRT, Z Modulation Amplifier & Calibrator

6.1 ATTENUATOR CH1 Drg. No. 1924

Input signals to CH1 BNC socket are connected to the attenuator via S1 input selector switch. In the DC position, signals pass directly to the attenuator or via C1 in the AC position. In the GND centre position, the input signal is disconnected, but the amplifier input is grounded. The attenuator switch S2A-C is in two sections. S2A & B attenuates the input in a 1, 10, 100, 1000 sequence, whilst S2C attenuates the signal in a repetitive 1, 2, 4 sequence. The result of cascading the two sections is to attenuate signals in a 1, 2, 4, 10 sequence over the 12 steps. As no attenuation takes place in the amplifier itself, problems of DC drift affecting the trace position when the attenuator is switched do not occur in the BWD 824. Response and constant input capacity is maintained at each attenuator step by adjustable series and shunt capacitors.

6.2 INPUT AMPLIFIER CH1 Drg. No. 1925

NOTE: As CH1 & 2 are similar, only CH1 is described.

The input amplifier is a balanced FET differential stage. Input protection is provided by R101 & C101 and reverse biased diodes D101 taken to -15V and D102 taken to +5.7V to prevent U101A gate from exceeding these limits. U101 A & B is a dual FET on a common substrate to minimise the effects of temperature drift on the trace position. RV102 Vernier gain control is located between the FET sources. R106 in series sets the maximum gain whilst R107 in parallel with RV102 sets the gain in calibrated position. RV101 DC balance preset is adjusted for zero trace movement when RV102 is varied.

The position control RV104 is in the centre of a network consisting of R110 and R111. Variation in the position of the wiper on RV104 will vary the ratio of the divider symmetrically and therefore the position voltage superimposed on the signal voltage at pins 1 and 14 of U102.

Inputs to the 733 IC amplifier U102 are directly coupled to U101 A & B drain loads R108 & 109. RV103 preset centres the vertical position range.

The stage gain of U102 is preset by RV105. The push pull output of U102 from pins 7 & 8 drives two circuits, trigger take off emitter follower U103A and the beam switching transistors U103B & C in IC U103.

6.3 BEAM SWITCH AMPLIFIERS

Two transistors in U103 are connected as a balanced series feedback pair with the collector of the switching transistor connected to the junction of R121 & 122 emitter resistors via R119. RV108 and C107 provide H.F. compensation for CH1 amplifier. Beam switching to select CH1 or CH2 is controlled by half of U203 'D' flip flop. CH1 drive is via R128 to pin 12 of U103 and CH2 via R167 to pin 12 of U153.

The collectors of the transistor pair in U103 and the corresponding pair in U153 are joined together via S152A & B invert switch which determines the polarity of CH2 signal. The collectors are taken directly to the bases of Q133 and 135 vertical output amplifier.

6.4 BEAM SWITCH CIRCUIT

The beam switch is controlled by switch S201A & B.

When selecting CH1 the free running/alternate oscillator U202 is disabled by holding pin 8 of U203 and simultaneously, pin 8 of U202 HI, latching the output of U203A at 13 HI and output 9/12 LO. CH1 is turned on and CH2 off.

To select CH2 only, pin 1 of U202 and pin 10 of U203 are held HI. This causes pins 9/12 to go HI and pin 13 LO, so turning CH2 on and CH1 off.

In the ALT mode, pin 1 of U202 is held HI so pin 3 and 5 are LO. A positive pulse on pin 6 from U304 time base gate via R332 at the start of the fly back period will cause pin 4 and 9 to go LO. As pin 8 is held LO via R212 and R213 the output at pin 10 will go HI and via R214 apply the pulse to the clock input of U203 at pin 11. Outputs at 13 and 9/12 will alternate from HI to LO at each clock pulse and so switch the amplifiers on or off alternately at the end of each time base sweep.

In the CHOP mode, pin 8 of U202 is grounded via R213 and 212 so that sections A, B & C of U202 can operate as an oscillator at approx. 300kHz.

The output pulse to pin 10 of U203 now causes the beam switch to change over every 3µsec approx. and so switch the amplifiers at this rate. To eliminate the smear during the switching action, a portion of the oscillator output is applied to pin 13 of U202 via C203. The output at pin 11 is a positive going pulse which overlaps the switching transient which is applied to the Z modulation amplifier to blank out the trace during this period.

6.5 OUTPUT AMPLIFIER

This is a push/pull circuit employing shunt feedback. Q133 and 135 are the amplifiers with Q132 and 136 constant current transistors which operate as pull up stages at high frequencies and Q131 and 134 current feedback transistors. The circuit provides a low output impedance to drive the CRT deflection plates.

Current through Q133 to 135 is set by the emitter resistors of Q132 and 136 together with their respective base divider networks. A slightly lower standing current is also supplied via R133 and 143 via Q131 and 134 to U103 transistor pair so that when the amplifier is in its quiescent state, no current flows through the feedback resistors R136 or 146.

At low frequencies, Q132 and 136 operate as constant current stages, so that only U103, 133 and 135 operate as amplifiers. However, at high frequencies, Q132 and 136 are driven via C131 and 133 respectively and supply a pull up current to the output load from C132 and 134 emitter bypass capacitors.

6.6 TRIGGER & X OUTPUTS

Transistors in U103 and 153 are connected as emitter followers. R130 is the emitter load for CH1. CH2 trigger output is also the drive for identical X-Y operation. Trigger take off is from the junction of R169 and 172, X take off is from RV158. R170 and RV159 adjust the current through R169 to set the X output to screen centre with no input signal and position control centered. CH1 or CH2 trigger signals are selected by S152C and supplied to the INT-EXT trigger select switch via C108.

6.7 TRIGGER & TIME BASE Drg No 1926

TRIGGER INPUT

S301A selects either the internal trigger signal from C108 or external signals from the front panel input via R301, R302 with C302 in parallel.

S301B passes the signal selected by S301A in the out position or a line frequency signal from the power transformer secondary via R401 when depressed. The selected trigger is applied to U301A amplifier and transistor A in U302 array via C305. DC and low frequency signals are supplied by U301A and mixed with the HF signals via U302A. R307 forms the emitter load of U302A and the mixing load of U301A. As the inverting feedback input is taken from the mixing point to pin 2 of U301A the output DC level is identical to the input. The trigger signal is taken to S301C polarity selector. Trigger level control is applied to the inverting input via R304 where it is mixed with the feedback signal through R305. The resultant output is applied to S301C via R308.

6.8 TRIGGER AMPLIFIER

Transistors U302B & C are a differential pair whose bases are connected to the + & - switch. When + is selected, the input signal passes to U302C and the level voltage to U302B. The reverse applies when - is selected. Current through the differential pair is set by R314 and RV302 emitter load.

6.9 TRIGGER LATCH

U302B & C collectors are taken to inputs of two OR/NOR ECL gates U303 wired with R310 and R311 to provide positive feedback from the OR outputs to the same input pin as the transistor collectors. RV302 is adjusted so that the current through R310 and R311 when no signal is present, is just above the input threshold of each gate.

When a positive signal appears at the trigger input, it will cause U302C to conduct, taking current away from U302B. However, it will not cause U303B to conduct, as another input at pin 13 is held HI by the output of U303A. When the signal swings negatively, U302B conducts and assuming pins 4 & 12 are low, the current through R310 will cause the U303A gate to conduct. Its output will fall and via R310 it will latch the gate in a LO state. This now releases pin 13 of U303B gate, so that the next positive swing of the trigger signal makes gate U303B latch and both gates will remain in this condition until reset.

Both the OR & NOR outputs of U303B are taken to Q301. When awaiting a trigger signal the OR Output is positive to the NOR output and Q301 is reverse biased. When U303B latches, the outputs change over and Q301 is pulled into conduction, its collector rises and switches gate U304D input HI. This in turn causes its output to fall to initiate the time base.

6.10 TV TRIGGER

When S301D is selected, a sync separator U302D is brought into operation to strip the sync pulses from the video waveform. U302C collector is switched via S301D from U303B gate to a collector load R317 and the signal developed across this is directly coupled to U302E. This transistor inverts the signal and it is then connected to U302D sync separator via R311 and C310. U302D is biased on by R320 so that negative going video signals will bias the transistor beyond cutoff and only sync signals will make it conduct and appear amplified and inverted at its collector to latch U303B gate to which it is connected. C311 connected to ground via time base switch wafer S371A/R removes the high frequency line sync pulses from U302D collector load and leaves only frame pulses over the time base range 0.1sec to 0.1msec. At time base speeds 50µsec to 0.2µsec, S371A/R is open circuit, so that the line pulses remain to provide the trigger signal.

6.11 AUTO TRIGGER

When operating with a continuous trigger source, Q301 conducts at the start of each sweep to initiate the time base. It also charges C315 via D304, holding input 8 of U304C HI. Therefore, the output at 10 is LO and does not affect gate U304D. However, when a trigger signal is not present, Q301 does not conduct allowing C311 to discharge through R328, pulling input 8 of U304C LO. As input 9 is held LO by U304B, the output at 10 will rise and pull U304D input HI, causing its output to fall and initiate a time base sweep. At the end of the sweep as described in 6.12, U304B output rises and in addition to the hold-off function also takes pin 9 of U304C HI, causing its output to fall, so removing the gate drive from U304D, forcing its output HI to allow the return trace to start.

When the return trace and hold-off period is finished, U304B output falls, pulling pin 9 LO and unless a trigger signal has been received to charge up C311, the LO at input 9 will cause the output at 10 to rise, pulling gate U304D HI to initiate another sweep.

6.12 TIME BASE

U305 is the sawtooth integrator which is gated on by U304D and off by Q303. Hold off during the return trace is controlled by Q302 with C313, C314, C374-6 and R329 timing components. Sweep time is controlled by C377A-E capacitors and R376A-H charging resistors supplied by a negative voltage from RV371 time base vernier control.

Operation is as follows:-

Assuming the circuit is in a quiescent condition, the arrival of a trigger signal will drive Q301 into conduction as in para 6.9. As the collector rises to approx +3V, pin 12 of U304D will be pulled HI, causing its output to fall. When pin 13 is LO the divider R333 and 334 will reverse bias D305 & D310.

U305 Bifet op amp is now left with a capacitor C377A-E as selected by S371B between output in 6 and inverting input pin 2. (Pin 3 is grounded via S371A/F). The timing resistor network R376A-H is also connected between pin 2 and a negative potential set by RV371 vernier control. As pin 2 is pulled negatively the output on pin 6 will rise. However, the timing capacitors C377 A-E will supply the inverted amplified output as negative feedback and due to the very high amplifier gain the resultant sawtooth waveform is extremely linear.

The output continues to rise until R339 and R338 divider pulls the base of Q303 HI. Its collector will fall pulling pin 5 of U304B LO and as pin 6 is already LO pin 4 switches to HI and latches the bistable pair in that condition via the direct connection to pin 3 of U304A.

The output of U304B resets U303A & B by taking pins 4 & 12 above the gate threshold voltage via R327. This in turn unlatches Q301, its collector falls so that it no longer holds pin 12 of U304D HI. As pin 9 of U304C has been taken HI by U304B output, pin 10 will fall so both inputs of U304D are LO, pin 13 switches HI and diode D305 is pulled into conduction by R333. When the inverting input of U305 is pulled positively, its output at 6 will fall and discharge the timing capacitors. A quiescent state is reached when the pull down current from U305 via diode D310 equals the current through R333.

During the sweep period, Q302 was pulled into conduction by base current through R340 clamping capacitors connected to Q302 collector at +0.2V. However, when U305 output falls to zero, Q302 is turned off, allowing the capacitors to be pulled positively by R329 which is connected to +15V. When the voltage on Q302 collector and pin 6 of U304B reaches approx +3V, U304B switches over, its output falls and pulls pin 3 of U304A LO.

6.12 TIME BASE cont'd

As pin 2 is already LO, the output at 1 switches to HI, pulls pin 5 HI and the bistable pair again are latched. With output at pin 4 LO the trigger latch U303 is released ready for the next trigger signal, pin 9 of U304C is set LO releasing the Auto gate. If C311 has not been charged up via D304 due to an absence of trigger signals, the two inputs will be LO, its output at 10 will be HI and pull pin 11 of U304D HI, switching 13 LO, releasing D305 & 310 so starting another sweep. If C311 was charged, the output at U304C pin 10 will remain LO and the next sweep will commence when U303 receives a signal, latches, pulls Q301 into conduction which in turn pulls pin 12 of U304D HI and starts the next sweep.

6.13 ALTERNATE DRIVE

The output of U304D provides the ALTERNATE drive for the vertical amplifier beam switch U202 & 203. The signal is fed into pin 6 of U202 via R332.

6.14 X-Y OPERATION

When the time base switch S371 is turned fully clockwise to X-Y, the timing capacitors C377 are replaced with a resistive feedback network consisting of R371 and R372. The junction of R371 and R372 are taken to S371A/R, where the rotor contact connects it back to S371B/F and then via the wiper arm to U305 inverting input. RV158 adjusts the gain and sets the X calibration, phase shift is preset by C371.

The X signal from CH2 taken from the junction of R169 and 170 to RV158 and then to pin 3 of U305 is normally grounded by S371A/R wafer, but disconnected in the X-Y position.

6.15 HORIZONTAL AMPLIFIER

The amplifier transistors Q304, 305, 307, 308, 310 and 311 are configured in a push pull series/shunt feedback circuit.

The input signal is applied to Q304 whilst the horizontal positioning voltage from RV304 is connected to the other side of the amplifier Q305 via emitter follower Q306.

Signals developed across Q304 and 305 collector loads R352 and 353 are applied directly to Q308 and 310 bases. Switch S303 changes the feedback ratio applied to Q304 and 305 emitters to change the gain by x5.

The collector loads of the deflection amplifier Q308 is R350 and 351 in series, whilst Q310 load is R354. Emitter followers Q307 and 311 connected in series with Q308 and 310 supply the horizontal deflection plate voltages and the feedback currents via R348 and 349.

6.16 POWER SUPPLIES

AC input voltage is taken to S401 on-off power switch (located on the rear of RV424 intensity control). It then passes through input fuse F401 to the transformer T401. The two primary windings are connected in series for 195 to 264V operation and in parallel for 98 to 132V.

The centre tapped secondary winding is full wave rectified to supply + & -22V (approx.). C401 filters the +ve rail and C402 the negative. The rails are stabilised by U401 & U402 to provide + & - 15V for direct connection to the amplifier and time base circuits and via resistors R421 and 422 with additional filtering by C421 to the DC to DC converter circuit.

6.17 DC-DC CONVERTER

The +90V, EHT rails and CRT heater supply are supplied from T421 transformer. This circuit uses a push/pull direct drive feedback oscillator operating at 22kHz approx., consisting of Q421 and 422 transistors with R424, R423 and D421 base supply divider. The +90V HT supply is full wave rectified by D422 and D423 and filtered back to the +15V rail to which the winding is connected. Additional filtering is provided by R445 and C323 on the main PCB.

The negative EHT winding is half wave rectified by D424 and filtered by C431, R431 and C432 before being applied to the CRT cathode. To provide additional stabilisation of the -1440V rail the ground end of the EHT winding is taken through transistor Q423 to ground. The negative EHT voltage is applied across the divider R428, RV421 and R427 and then returned to the +90V rail. Any variation at the junction of R428 and RV421 is fed to Q424 base and then via its emitter to Q423 base to control its conduction and stabilise the supply against changes in beam current.

The PDA voltage is obtained by a voltage tripler C427, C428 and C429, D425, D426 & D427. The +4700V supply is filtered by R432 and C430 and supplied to the PDA via the CRT side connector.

6.18 CRT & Z MODULATION AMPLIFIER

The 140CG P31 domed mesh PDA CRT is supplied by the -1440V rail directly to its cathode. Its grid voltage is obtained by demodulating a signal derived from the 22kHz converter winding. Focus voltage is tapped off the divider R433, RV423 and R434. Geometry is preset whilst the astigmatism voltage is taken from RV132 preset potentiometer on the rear panel.

The Z or intensity modulation circuit derives its voltage from the +90 Volt transformer output winding. It is taken through R430 to D430 which through RV422 preset sets the maximum modulation voltage available to blank the CRT.

Q425, 426 and 427 modulation amplifier is a shunt feedback stage. Q425 supplies a constant current at low frequencies, Q427 emitter follower drives both Q426 amplifier directly and Q425 via C437 to provide a push/pull drive at high frequencies. Input signals to Q427 base are supplied via D432 which prevents Q426 amplifier from saturating. Four signals - intensity voltage, external Z input via R443, time base blanking via R330 and chopped blanking via R208 are combined at the current input drive to Q427.

The combined current drive from the signal causes Q426 collector to swing from approx +5V to +50V to modulate via D431 the clipped 22kHz square wave at R430 and D430 junction.

High frequency signals drive the CRT grid directly via C435 whilst low frequency modulated signals are supplied by C434 to D428 and D429 demodulator diodes.

D428 conducts on positive signals, DC restoring the waveform to the CRT cathode which is then conducted via D429 to combine with the AC coupled component at the CRT grid.

6.19 PROBE ADJUST VOLTAGE

The second 'D' flip flop U203B is connected to square off a 17V AC waveform derived from the power transformer secondary. The waveform is filtered by R219 and C209 and applied to the reset input pin 4. The rectangular output at pin 2 is attenuated to approx. 0.5V p-p by R216 & 218 before being applied to the front panel output socket.

7. ADJUSTMENTS & MAINTENANCE

Should the BWD 824 require re-calibration, as for example after repairs, etc. a number of preset controls are fitted which may be adjusted as detailed in the following section.

Before removing the cover, disconnect the instrument from the mains. Remove the four screws holding the feet, the handle screws and the two side screws. The cover may then be slipped off to the rear of the instrument.

To aid fault finding and alignment, the voltages and waveforms present at various points are shown on the circuits.

7.1 ALIGNMENT PROCEDURE

Before attempting re-alignment of any section of this Oscilloscope, check the instrument's general operating characteristics and correct any apparent faults. Also check DC rails as variation in supply voltages caused by a fault may result in miscalibration.

7.2 GENERAL CHECK OF CONTROLS

- a. Intensity: Linear control over intensity range.
- b. Focus: Approx. centre with adjustment either side.
- c. x1-x5 Hor.Mag: Trace should expand equally either side of centre.
- d. Vert. Positions: Traces should move equally off screen above and below centre.
- e. Trigger Level: With atten. at 0.1V feed CAL signal into CH1 and CH2 inputs, check AUTO and Level Select operation.
- f. + - Switch: Set up as for e, trigger point should change over as indicated by switch.

7.3 EQUIPMENT REQUIRED FOR COMPLETE CALIBRATION

DVM with High
Voltage Probe:

Pulse Generator: 5nsec Rise Time.

Voltage Calibrator: 1mV to 100V p- 0.25% accuracy.

Sine Wave Generator: 1Hz to 1MHz (BWD 141 or BWD 160A).

Constant Amplitude
Generator: 50kHz to 50MHz. 3% amplitude level accuracy.

Time Marker Generator: 40nsec to 1 sec/pulse. 0.1% accuracy.

7.4 POWER SUPPLIES

With AC power applied, switch the instrument on and allow it to stabilise for five minutes before making any adjustments. The + & - 15V rails are set by the regulator I.C.'s and are not adjustable. They should be within $\pm 0.6V$. +90V is not adjustable being supplied by the converter transformer T421. The voltage should be 90V $\pm 3V$.

The +5.7V rail is also preset by fixed components R201 & 202 supplying the reference to IC U201 +5.7V regulator.

EHT The -ve CRT supply is set to -1440V \pm 10V by RV421 on the converter board. The voltage should be monitored at the CRT cathode pin on the converter board. (Brown wire).

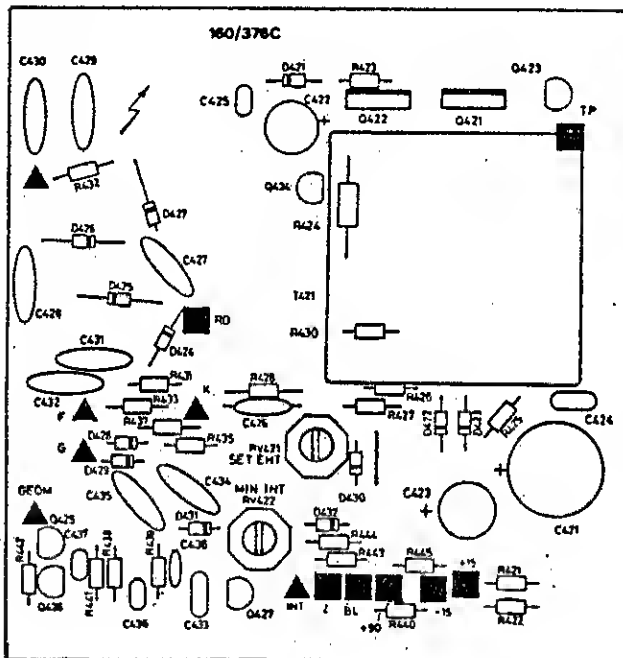
DANGER The PDA +4.7kV voltage remains after the instrument has been switched off as the only discharge path is reverse diode or filter capacitor leakage.

Therefore discharge the PDA supply on the rear converter power supply board before working on it via a 1Mohm resistor to chassis-

NEVER DISCHARGE DIRECTLY TO CHASSIS VIA A SCREWDRIVER, ETC. AS THIS MAY DAMAGE THE INSTRUMENT.

7.5 CRT TRACE ALIGNMENT

Trace rotation preset on rear panel should be set so that a single undeflected trace aligns precisely with the horizontal centreline of the graticule.



Next feed a 1kHz sine wave signal into the CH1 and adjust the waveform to fill screen. Time base to 1msec, VERNIER CAL.

Rear panel astigmatism preset control is adjusted in conjunction with the FOCUS control to obtain the best resolution over the entire screen area at normal viewing intensity. Geometry voltage is fixed at +45V approx.

Set Intensity control to minimum and adjust RV422 to just blank the trace when the time base is turned to 1 sec/div.

7.6 VERTICAL ALIGNMENT

a. Centre each trace in turn with vernier at 2mV. Turn vernier to CAL, if trace moves, recentre with the CH1 balance preset RV101 and RV151 for CH2. Repeat until no movement occurs.

b. With vernier to CAL and attenuator to 5mV/div, apply a 1kHz 25mV p-p calibration square wave to inputs. Adjust RV105 (CH1) & RV155 (CH2) for 5 div deflection.

Turn verniers to 2mV, apply 10mV p-p. Set RV106 (CH1) & RV156 (CH2) for 5 div deflection. Repeat until correct.

c. Remove input signal and check that the position control moves the trace equally above and below the centre line. Correct with RV103 CH1 or 153 CH2 if necessary.

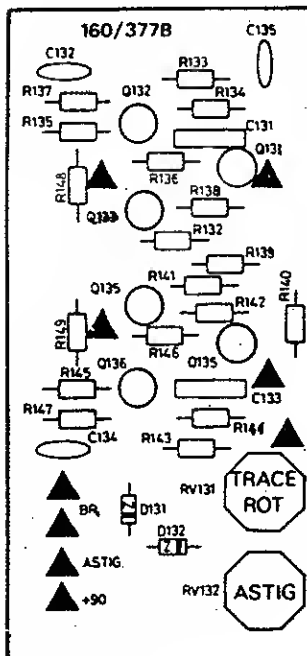


Fig 7-1 Converter & EHT Board

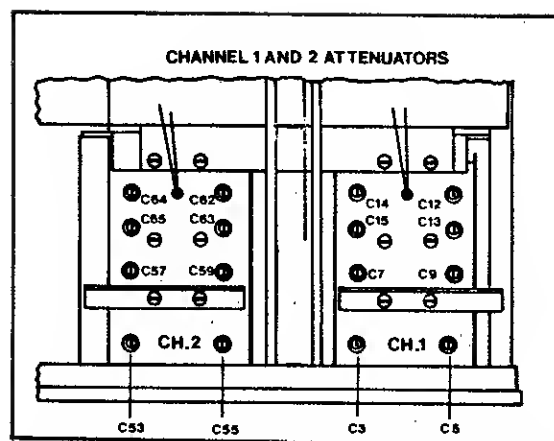
Fig 7-2 Vertical Output Board

7.7 ATTENUATOR ALIGNMENT

The following figures indicate the input voltages, attenuator settings and the capacitors, which compensate the attenuator response. Figures in brackets are for CH2.

Attenuator steps not listed have no adjustment. They are automatically aligned at other settings.

Fig 7-3 Channel 1 & 2 Attenuators



d. With attenuators at 50mV and vernier to CAL apply a correctly terminated 1MHz 5nsec rise time square wave to CH1 input. Set amplitude for 6 div deflection. Adjust RV108 and C107 for best square wave response with a sharp wave front, but minimum aberration at the corner.

Repeat for CH2 adjusting RV160 and C156.

e. Bandwidth check. Apply a 50kHz reference sine wave to CH1. Set attenuator to 50mV/div. Set amplitude to 6 div. Increase oscillator frequency. Amplitude should not drop below 4.2 div. deflection (-3db) at 35MHz. Repeat for CH2.

ATTENUATOR SETTING	INPUT VOLTAGE	ADJUST FOR SQUARE WAVE		ADJUST FOR INPUT CAPACITANCE	
5mV	-	-	-	-	
10mV	50mV	C14	(64)	-	
20mV	100mV	C12	(62)	-	
50mV	250mV	C7	(57)	C9	(59)
0.1	0.5V	C15	(65)	-	
0.2	1V	C13	(63)	-	
0.5	2.5V	C3	(53)	C5	(55)

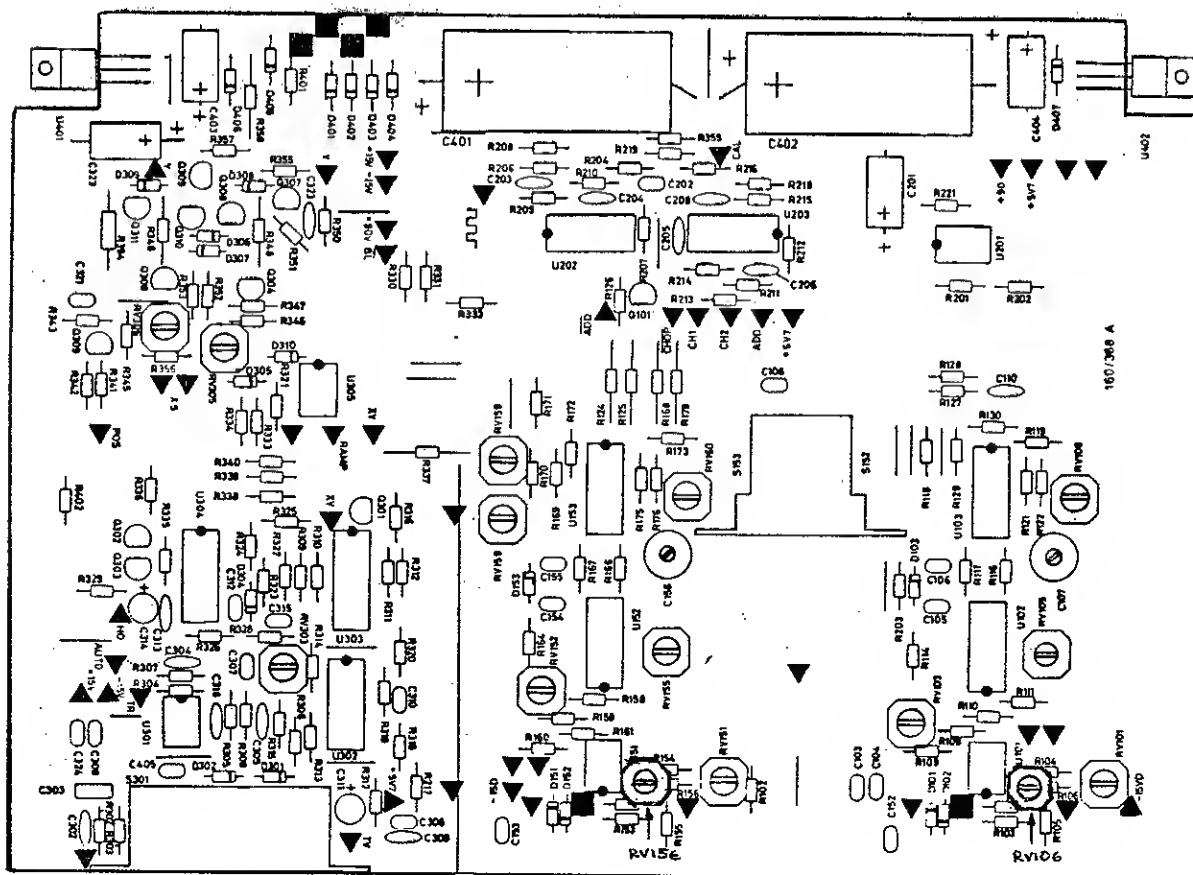


Fig 7-4
Main PCB

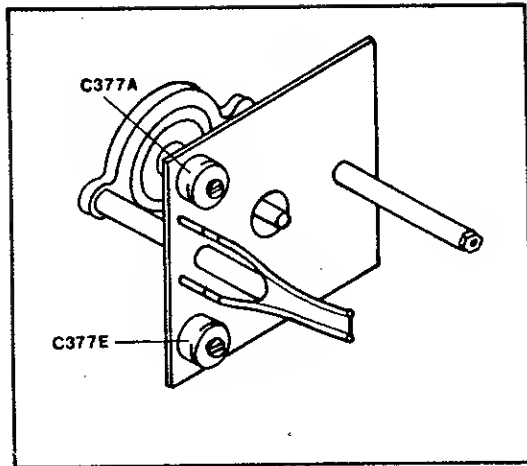


Fig 7-5 Time Base Switch

7.8 TIME BASE ALIGNMENT

a. Turn time range to 1msec/div, vernier to Cal position. Apply 1msec pulses and lock display. Adjust RV306 for 1 pulse/div.

b. Increase input pulses to 200 μ sec then pull out the horizontal position-control for x5 magnification. Adjust RV305 for 1 pulse per graticule division. Return to x1 magnification.

c. Turn time base to 0.2 μ sec/div, increase input pulse to 0.2 μ sec (5MHz). Adjust C377A on rear of time base switch for 1 per div.

d. Turn time base to 10 μ sec/div and apply 10 μ sec pulses. Adjust C377E on rear to time base switch for calibration. Check calibration from 10 μ sec to 0.5 μ sec and set C377E for best overall calibration.

7.9 X-Y ADJUSTMENT

a. Switch Vertical Display to CH1. Position CH1 trace in centre of screen (AUTO operation, no input signal). Now turn time base switch to X-Y position and pull out horizontal position control for x5 mag, control centred.

Next set both attenuators to 5mV/div, vernier to Cal. DC coupled, then feed into CH1 & CH2 a 30mVp-p 1kHz sine wave signal from a constant amplitude generator, to produce a diagonal line on the CRT. Centre trace horizontally on CRT with RV159.

b. Calibration. Switch CH1 to GND to leave a horizontal line on the CRT. Adjust RV158 for 6 div horizontal deflection.

c. Horizontal bandwidth. From a reference of 50kHz at 6 Div the trace should not reduce to less than 4.2 div before 1.0MHz.

7.10 TRIGGER SENSITIVITY

a. Operate the oscilloscope in the dual trace mode with the time base at 5msec/div, normal +ve internal trigger with level select knob centred. Connect a 50Hz sine wave to CH1 and adjust for 8 div deflection. Lock trace with trigger level control. Now adjust RV302 to present a stable lock with no double triggering as the LEVEL control is adjusted over the entire waveform amplitude and with either + or - slope selected.

b. Trace should be capable of locking over a frequency range from 5Hz to 40MHz with 1 div deflection. When signal level is increased, upper frequency limit will extend past 50MHz.

c. With a 50kHz sine wave input, increase deflection to 8 div. Check that level control operates over the full range either + or - polarity is selected.

d. Parallel the input signal via a T-piece to both CH1 and EXT TRIG input socket. Select EXT TRIG, then adjust signal level to 0.25V p-p. EXT TRIG should operate from 5Hz to 40MHz.

7.11 T.V. TRIGGER CHECK

Apply a composite video waveform to CH1. Adjust amplitude for 2 div. deflection, time base to 2msec, TV trigger button selected, Trigger Level to AUTO. The frame signal will be displayed. Increase time base speed to 50usec or faster and the line signal will be displayed. Trigger Level may be employed to lock video signals 2 div to 8 div deflection.

The BWD 824 Oscilloscope is now fully aligned.

8.1 ORDERING REPLACEMENT PARTS

Changes to BWD instruments are sometimes made to accommodate improved components as they become available and to incorporate the latest improvements developed by our engineering department. It is therefore essential, when ordering parts, to include the following information in your order:-

- a. Instrument type (include modification or option numbers if applicable).
- b. Instrument serial number.
- c. A description of the part and its component number.
- d. BWD instrument part number where listed.

8.2 MANUFACTURER'S CODE

The Mfr. Index for the Components Parts List is located after this page. The index provides codes and names of manufacturers listed in the Components Parts List.

8.3 PACKAGING FOR SHIPMENT

If the instrument is to be returned to BWD Industries Ltd. for service, attach a tag showing the name of an individual who can be contacted. Include instrument Serial Number and a description of the service required. Surround the instrument with polyethylene sheeting to protect its finish.

Use the original packing, if it is available. Otherwise, pack in a strong corrugated carton or wooden crate. Pack at least 8cm of foam or other packing around the instrument to firmly support it in the box.

PARTS LISTS**Component Designations:**

A	Assembly	Q	Transistor
C	Capacitor	R	Resistor
D	Diode	RV	Variable Resistor
E	Misc. Elec. Part	S	Switch
F	Fuse	T	Transformer
J	Jack (Socket)	TH	Thermistor
L	Indicator	VDR	Volt Dependent Resistor
P	Plug		

Abbreviations:

Amp	Ampere	MPC	Metalised Polyester Capacitor
CF	Carbon Film	NPO	Zero Temperature Co-efficient
c	Carbon	ns	Nano-second
CDS	Ceramic Disc	p	Peak
cer	Ceramic	pF	Pico Farad = 10^{-12} F
DPST	Double Pole Single Throw	preset	Internal Preset
DPDT	Double Pole Double Throw	PYE	Polyester
elec	Electrolytic	pot	Potentiometer
FET	Field Effect Transistor	PCB	Printed Circuit Board
kHz	Kilohertz = 10^3 Hz	PIV	Peak Inverse Voltage
k	kilohm = 10^3 ohm	PYS	Polystyrene
Lin	Linear	p-p	Peak to Peak
Log	Logarithmic Taper	R	Ohms
m	Milli = $\times 10^{-3}$	rot	Rotary
MHz	Mega-hertz = 10^6 Hz	rms	Root Mean Squared
MF	Metal Film	si	Silicon
mA	Milliampere = 10^{-3} Amp	Ta	Tantalum
M	Megohm = 10^6 ohm	tol	Tolerance
mfr	Manufacturer	trim	Trimmer
MO	Metal Oxide	V	Volts
MHT	Polyester/Paper Capacitor	var	Variable
		W	Watt

Manufacturer's Abbreviations:

ALPS	Alps Electronics	MOT	Motorola Semiconductor Inc.
BWD	BWD Industries Ltd.	NS	NS Electronics Pty Ltd
ELN	Elna Capacitors (Soanar)	NSF	NSF Limited
F	Fairchild	PH	Philips Industries Limited
IRH	IRH Components P/L	SON	Soanar Electronics P/L
ERIE	Erie Capacitors	SIEM	Siemens Industries Limited
NOBLE	Noble Electronics	STET	Stettner Capacitors Limited

BWD 824 Parts List

CCT REF	DESCRIPTION			MFR.	PART NO.
	<u>RESISTORS</u>				
R1	10R	5%	1/4W	MF	
R2	990k	1%	1/4W	MF	
R3	10k1	1%	1/4W	MF	
R4	111k	1%	1/4W	MF	
R5	900k	1%	1/4W	MF	
R6	500k	1%	1/4W	MF	
R7					
R8	750k	1%	1/4W	MF	
R9					
R10	333k	1%	1/4W	MF	
R11	1M	1%	1/4W	MF	
R12	1M	1%	1/4W	MF	
R13	33R	5%	1/4W	MF	
R14	220k	5%	1/4W	MF	
R15	33R	5%	1/4W	MF	
R16	56R	5%	1/4W	MF	
R51	10R	5%	1/4W	MF	
R52	990k	1%	1/4W	MF	
R53	10k1	1%	1/4W	MF	
R54	111k	1%	1/4W	MF	
R55	900k	1%	1/4W	MF	
R56	500k	1%	1/4W	MF	
R57					
R58	750k	1%	1/4W	MF	
R59					
R60	333k	1%	1/4W	MF	
R61	1M	1%	1/4W	MF	
R62	1M	1%	1/4W	MF	
R62	33R	5%	1/4W	MF	
R64	220k	5%	1/4W	MF	
R65	33R	5%	1/4W	MF	
R66	56R	5%	1/4W	MF	
R101	220k	5%	1/4W	MF	
R102	100R	5%	1/4W	MF	
R103	10k	5%	1/4W	MF	
R104	10k	5%	1/4W	MF	
R105	39R	5%	1/4W	MF	
R106					
R107	2k7	5%	1/4W	MF	
R108	680R	5%	1/4W	MF	
R109	680R	5%	1/4W	MF	
R110	68k	5%	1/4W	MF	
R111	68k	5%	1/4W	MF	
R112	160R	5%	1/4W	CF	
R113					
R114	1k2	1%	1/4W	MF	
R115	160R	5%	1/4W	CF	
R116	39R	5%	1/4W	MF	
R117	39R	5%	1/4W	MF	

CCT REF	DESCRIPTION			MFR.	PART NO.
R118	10R	5%	1/4W	MF	
R119	560R	5%	1/4W	MF	
R120					
R121	100R	5%	1/4W	MF	
R122	100R	5%	1/4W	MF	
R123					
R124	390R	5%	1/4W	MF	
R125	390R	5%	1/4W	MF	
R126	47k	5%	1/4W	MF	
R127	15k	5%	1/4W	MF	
R128	2k2	5%	1/4W	MF	
R129	82R	5%	1/4W	MF	
R130	3k9	5%	1/4W	MF	
R131					
R132	22k	5%	1/4W	MF	
R133	4k7	5%	1/4W	MF	
R134	47k	5%	1/4W	MF	
R135	10k	5%	1/4W	MF	
R136	3k3	5%	1/4W	MF	
R137	820R	1%	1/4W	MF	
R138	68R	1%	1/4W	MF	
R139	18k	5%	1/4W	MF	
R140	10R	5%	1/4W	MF	
R141	220R	5%	1/4W	MF	
R142	68R	5%	1/4W	MF	
R143	4k7	5%	1/4W	MF	
R144	47k	5%	1/4W	MF	
R145	10k	5%	1/4W	MF	
R146	3k3	5%	1/4W	MF	
R147	820R	5%	1/4W	MF	
R148	8k2	5%	1/4W	MF	
R149	8k2	5%	1/4W	MF	
R150					
R151	220k	5%	1/4W	MF	
R152					
R153	10k	5%	1/4W	MF	
R154	10k	5%	1/4W	MF	
R155	39R	5%	1/4W	MF	
R156					
R158	680R	5%	1/4W	MF	
R159	680R	5%	1/4W	MF	
R160	68k	5%	1/4W	MF	
R161	68k	5%	1/4W	MF	
R162					
R163					
R164	1k2	5%	1/4W	MF	
R165	160R	5%	1/4W	CF	
R166	39R	5%	1/4W	MF	
R167	39R	5%	1/4W	MF	
R168	15k	1%	1/4W	MF	
R169	3k9	5%	1/4W	MF	
R170	6k8	5%	1/4W	MF	
R171	10R	5%	1/4W	MF	
R172	82R	5%	1/4W	MF	
R173	560R	5%	1/4W	MF	
R174					

CCT REF	DESCRIPTION			MFR.	PART NO.
R175	100R	5%	1/4W	MF	
R176	100R	5%	1/4W	MF	
R177					
R178	2k2	5%	1/4W	MF	
R179					
R180					
R201	10k	5%	1/4W	MF	
R202	6k2	1%	1/4W	MF	
R203					
R204	39R	5%	1/4W	MF	
R205					
R206	47k	5%	1/4W	MF	
R207	47k	5%	1/4W	MF	
R208					
R209	10k	5%	1/4W	MF	
R210	10k	5%	1/4W	MF	
R211	47k	5%	1/4W	MF	
R212	10k	5%	1/4W	MF	
R213	47k	5%	1/4W	MF	
R214	10k	5%	1/4W	MF	
R215	56k	5%	1/4W	MF	
R216	510R	1%	1/4W	MF	
R217	330k	5%	1/4W	MF	
R218	4k7	5%	1/4W	MF	
R219	56k	5%	1/4W	MF	
R220					
R221	10R	5%	1/4W	MF	
R301	180R	5%	1/4W	MF	
R302	470k	5%	1/4W	MF	
R303	560k	5%	1/4W	MF	
R304	47k	5%	1/4W	MF	
R305	4k7	5%	1/4W	MF	
R306	180k	5%	1/4W	MF	
R307	1k	5%	1/4W	MF	
R308	39R	5%	1/4W	MF	
R309	2k7	5%	1/4W	MF	
R310	180R	5%	1/4W	MF	
R311	180R	5%	1/4W	MF	
R312	2k7	5%	1/4W	MF	
R313	39R	5%	1/4W	MF	
R314	2k2	5%	1/4W	MF	
R315	39R	5%	1/4W	MF	
R316	180R	5%	1/4W	MF	
R317	1k2	5%	1/4W	MF	
R318	3k9	5%	1/4W	MF	
R319	2k7	5%	1/4W	MF	
R320	2M7	5%	1/4W	CF	
R321	180R	5%	1/4W	MF	

CCT REF	DESCRIPTION				MFR.	PART NO.
R322						
R323	3k9	5%	1/4W	MF		
R324	82R	5%	1/4W	MF		
R325	1k	5%	1/4W	MF		
R326	39k	5%	1/4W	MF		
R327	4k7	5%	1/4W	MF		
R328	5M6	5%	1/4W	CF		
R329	56k	5%	1/4W	MF		
R330	3k3	5%	1/4W	MF		
R331	4k7	5%	1/4W	MF		
R332	12k	5%	1/4W	MF		
R333	3k9	5%	1/4W	MF		
R334	1k5	5%	1/4W	MF		
R335	1k5	5%	1/4W	MF		
R336	5M6	5%	1/4W	CF		
R337	39R	5%	1/4W	MF		
R338	15k	5%	1/4W	MF		
R339	2k7	5%	1/4W	MF		
R340	47k	5%	1/4W	MF		
R341	33k	5%	1/4W	MF		
R342	33k	5%	1/4W	MF		
R343	6k8	5%	1/4W	MF		
R344						
R345	18k	5%	1/4W	MF		
R346	330R	5%	1/4W	MF		
R347	1k5	5%	1/4W	MF		
R348	39k	5%	1/4W	MF		
R349	39k	5%	1/4W	MF		
R350	10k	5%	1/4W	MF		
R351	8k2	5%	1/4W	MF		
R352	1k	5%	1/4W	MF		
R353	1k	5%	1/4W	MF		
R354	18k	5%	1W	MF		
R355	220R	5%	1/4W	MF		
R356	3k9	5%	1/4W	MF		
R357	12k	5%	1/4W	MF		
R358	10k	1%	1/4W	MF		
R359	10R	5%	1/4W	MF		
R360						
R371	10k	5%	1/4W	MF		
R372	4k7	5%	1/4W	MF		
R373	2k7	5%	1/4W	MF		
R374	1k5	5%	1/4W	MF		
R375	750R	1%	1/4W	MF		
R376	A-H	THICK FILM NETWORK			BWD	010-010
R377						

CCT REF	DESCRIPTION				MFR.	PART NO.
R401	560k	5%	1/4W	MF		
R402	18k	5%	1/4W	MF		
R403	2k2	5%	1/4W	MF		
R421	2R2	5%	1/4W	MF		
R422	2R2	5%	1/4W	MF		
R423	56R	5%	1/4W	MF		
R424	4k7	5%	1W	MF		
R425	82k	5%	1/4W	MF		
R426	150k	5%	1/4W	MF		
R427	560k	5%	1/4W	MF		
R428	10M	5%	1/2W	MF	PH	VR 37
R429						
R430	330k	5%	1/4W	MF		
R431	22k	5%	1/4W	MF		
R432	2M2	5%	1/2W	MF	PH	VR 37
R433	2M2	5%	1/2W	MF	PH	VR 37
R434	8M2	5%	1/2W	MF	PH	VR 37
R435	10k	5%	1/4W	MF		
R436						
R437	10M	5%	1/4W	CF		
R438	12k	5%	1/4W	MF		
R439	33k	5%	1/4W	MF		
R440	6k8	5%	1/4W	MF		
R441	82k	5%	1/4W	MF		
R442	82k	5%	1/4W	MF		
R443	10k	5%	1/4W	MF		
R444	15k	5%	1/4W	MF		
R445	10R	5%	1/4W	MF		

CAPACITORS

C1	47n	10%	630V	GREENCAP	ELNA	TYPE NH
C2						
C3	0.8-5p	TRIM			PH	2222-801-96003
C4	10p	10%	630V	NPO	CDS	
C5	1.2-10p	TRIM			STET	310601240
C6	3p3	10%	630V	NPO	CDS	
C7	1.2-10p	TRIM			STET	310601240
C8	10p	5%	630V	NPO	CDS	
C9	1.2-10p	TRIM			STET	310601240
C10	15p	5%	630V	NPO	CDS	
C11	4p7	10%	630V	NPO	CDS	
C12	1.2-10p	TRIM			STET	310601240
C13	1.2-10p	TRIM			STET	310601240
C14	1.2-10p	TRIM			STET	310601240
C15	0.8-5p	TRIM			PH	2222-801-96003
C16	390p	BUTTON MICA			ERIE	654-017
C17	8p2	10%	630V	NPO	CDS	
C18	6p8	10%	630V	NPO	CDS	

CCT REF	DESCRIPTION					MFR.	PART NO.
C51	47n	10%	630V	GREENCAP	ELNA	TYPE NH	
C52							
C53	0.8-5p	TRIM			PH	2222-801-96003	
C54	10p	10%	630V	NPO CDS			
C55	1.2-10p	TRIM			STET	310601240	
C56	3p3	10%	630V	NPO CDS			
C57	1.2-10p	TRIM			STET	310601240	
C58	10p	5%	630V	NPO CDS			
C59	1.2-10p	TRIM			STET	310601240	
C60	15p	5%	630V	NPO CDS			
C61	4p7	10%	630V	NPO CDS			
C62	1.2-10p	TRIM			STET	310601240	
C63	1.2-10p	TRIM			STET	310601240	
C64	1.2-10p	TRIM			STET	310601240	
C65	0.8-3p	TRIM			PH	2222-801-96003	
C66	390p	BUTTON MICA			ERIE	654-017	
C67	8p2	10%	630V	NPO CDS			
C68	6p8	10%	630V	NPO CDS			
C101	10n	10%	630V	GREENCAP	ELNA	TYPE NH	
C102							
C103	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C104	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C105	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C106	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C107	5-65p	FILM	TRIM		PH	2222-808-32659	
C108							
C109							
C110	22pF	5%	630V	N750 CDS			
C131	10nF	10%	100V	GREENCAP	SON	TYPE N	
C132	100nF	10%	100V	GREENCAP	SON	TYPE N	
C133	10nF	10%	100V	GREENCAP	SON	TYPE N	
C134	100nF	10%	100V	GREENCAP	SON	TYPE N	
C151	10n	10%	630V	GREENCAP	ELNA	TYPE NH	
C152	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C153	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C154	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C155	100n		63V	SIBABIT	SIEM	B37449-C6104-S2	
C156	5-65p	FILM	TRIM		PH	2222-808-32659	
C157							
C209	10n	10%	100V	GREENCAP	ELNA	TYPE N	

CCT REF	DESCRIPTION					MFR.	PART NO.
C301							
C302	6p8	10%	630V	NPO	CDS		
C303	100n	10%	400V		MKT	SIEM	
C304	10p	10%	630V	NPO	CDS		
C305	330p	20%	630V	YE	CDS		
C306	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C307	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C308	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C309	680p	20%	630V	YE	CDS		
C310	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C311	220n		40V	ELECTRO	RB	ELNA	
C312	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C313	220p	20%	630V	YE	CDS		
C314	1u	50V	ELECTRO		RBLL	ELNA	
C315							
C316							
C320							
C321	100n	63V	SIBABIT	SIEM			B37449-C6104-S2
C322	82p	5%	630V	N750	CDS		
C323	10u		160V	ELECTRO		PH	RT
C324	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C325							
C371	82p	10%	630V	N750	CDS		
C372							
C373							
C374	470p	20%	630V	YE	CDS		
C375	2n2	10%	100V	GREENCAP		ELNA	TYPE N
C376	47n	10%	100V	GREENCAP		ELNA	TYPE N
C377A	2-22p	FILM	TRIMMER			PH	2222-808-11229
C377B	1uF]	1%	100V	MKT		SIEM	SELECTED
C337C	10n]	PAIR	400V	MKT		SIEM	SELECTED
C377D	82pF	5%	250V	POLYSTYRENE			
C377E	2-22p	FILM	TRIMMER		PH		2222-808-11229
C401	2500uF		25V	ELECTRO		ELNA	RT
C402	2500uF		25V	ELECTRO		ELNA	RT
C403	100uF		25V	ELECTRO		ELNA	RB
C404	100uF		25V	ELECTRO		ELNA	RB
C405	100n		63V	SIBABIT		SIEM	B37449-C6104-S2
C421	1000u		35V	ELECTRO		ELNA	RB
C422	100u		25V	ELECTRO		ELNA	RB
C423	22u		160V	ELECTRO		PH	RT

CCT REF	DESCRIPTION				MFR.	PART NO.
C424	100n	10%	100V	GREENCAP	ELNA	TYPE N
C425	100n	10%	100V	GREENCAP	ELNA	TYPE N
C426	1n		2KV	CDS	ERIE	
C427	10n		3KV	CDS	ERIE	
C428	10n		3KV	CDS	ERIE	
C429	6n8		5KV	CDS	ERIE	
C430	6n8		5KV	CDS	ERIE	
C431	20n		2KV	CDS	ERIE	
C432	20n		2KV	CDS	ERIE	
C433	100n	10%	100V	GREENCAP	ELNA	TYPE N
C434	1n	20%	2KV	CDS	ERIE	
C435	10n	20%	3KV	CDS	ERIE	
C436	100n	10%	100V	GREENCAP	ELNA	TYPE N
C437	100n	10%	100V	GREENCAP	ELNA	TYPE N
C438	0.62p	+/- .1p	630V	NPO CDS	ERIE	
C439	1n	20%	630V	YE CDS		
C440	22n	10%	100V	GREENCAP	ELNA	TYPE N

POTENTIOMETERS

RV101	500R	CERMET PRESET		NOBLE	VTP
RV102	10k	LINEAR SWITCH POT		ALPS	
RV103	50R	CERMET PRESET		NOBLE	VTP
RV104	10k	LINEAR CARBON POT		NOBLE	VMU
RV105	500R	CERMET PRESET		NOBLE	VTP
RV106	500R	CERMET PRESET		NOBLE	VTP
RV107					
RV108	1k	CERMET PRESET		NOBLE	VTP
RV109					
RV110					
RV131	5k	CERMET PRESET		NOBLE	VTP
RV132	200k	CERMET PRESET		NOBLE	VTP
RV151	500R	CERMET PRESET		NOBLE	VTP
RV152	10k	LINEAR SWITCH POT		ALPS	
RV153	50R	CERMET PRESET		NOBLE	VTP
RV154	10k	LINEAR CARBON POT		NOBLE	VMU
RV155	500R	CERMET PRESET		NOBLE	VTP
RV156	500R	CERMET PRESET		NOBLE	VTP
RV157					
RV158	2k	CERMET PRESET		NOBLE	VTP
RV159	10k	CERMET PRESET		NOBLE	VTP
RV160	1k	CERMET PRESET		NOBLE	VTP
RV301	500k	LINEAR SWITCH POT	DPDT	NOBLE	VTP
RV302	5k	CERMET PRESET		NOBLE	VTP
RV303					
RV304	10k	LINEAR POT		NOBLE	VMU

BW0 824 Parts List

CCT REF	DESCRIPTION		MFR.	PART NO.
RV305	200R	CERMET PRESET	NOBLE	VTP
RV306	1k	CERMET PRESET	NOBLE	VTP
RV307				
RV371	5k	LINEAR SWITCH POT	NOBLE	VTP
RV421	200k	CERMET PRESET	NOBLE	VTP
RV422	200k	CERMET PRESET	NOBLE	VTP
RV423	3M	LINEAR CARBON POT	NOBLE	VCU
RV424	10k	LINEAR SWITCH POT	RADIOHM	DPST ROTARY

SEMI CONDUCTORS

U101	NPD8303	DUAL FET	NS
U102	uA733	AMPLIFIER	FAIR
U103	CA3086	TRANSISTOR ARRAY	RCA
U151	NPD8303	DUAL FET	NS
U152	uA733	AMPLIFIER	FAIR
U153	CA3086	TRANSISTOR ARRAY	RCA
U201	LF 351 or LF 356	FET OP AMPLIFIER	NS
U202	CD4001B	CMOS	
U203	CD4013B	CMOS	
U301	LF 353	DUAL OP-AMP	NS
U302	CA3086	TRANSISTOR ARRAY	RCA
U303	MC10109	ECL GATES	MOT
U304	74CH02	CMOS GATES	
U305	LF 356	FET OP AMPLIFIER	NS
U401	uA7815	+15V REG	
U402	uA7915	-15V REG	

CCT REF	DESCRIPTION		MFR.	PART NO.
Q101	PN4249	PNP TRANSISTOR		
Q131	PN4121	PNP TRANSISTOR		
Q132	PN4121	PNP TRANSISTOR		
Q133	MPS6544	NPN TRANSISTOR		
Q134	PN4121	PNP TRANSISTOR		
Q135	MPS6544	NPN TRANSISTOR		
Q136	PN4121	PNP TRANSISTOR		
Q301	PN4258	PNP TRANSISTOR		
Q302	BC547	NPN TRANSISTOR		
Q303	BC547	NPN TRANSISTOR		
Q304	PN4249	PNP TRANSISTOR		
Q305	PN4249	PNP TRANSISTOR		
Q306	BC547	NPN TRANSISTOR		
Q307	2N5550	NPN TRANSISTOR		
Q308	2N5550	NPN TRANSISTOR		
Q309	PN4249	PNP TRANSISTOR		
Q310	2N5550	NPN TRANSISTOR		
Q311	2N5550	NPN TRANSISTOR		
Q421	2N3055	NPN TRANSISTOR] MATCHED PAIR	
Q422	2N3055	NPN TRANSISTOR		
Q423	2N5550	NPN TRANSISTOR		
Q424	PN3645	PNP TRANSISTOR		
Q425	PN3645	PNP TRANSISTOR		
Q426	2N5550	NPN TRANSISTOR		
Q427	BC547	NPN TRANSISTOR		
D101	IN3595	DIODE		
D102	IN3595	DIODE		
D131	BZX79/C11V	ZENER DIODE		PH
D132	BZX79/C11V	ZENER DIODE		PH
D151	IN3595	DIODE		
D152	IN3595	DIODE		

BWD 824 Parts List

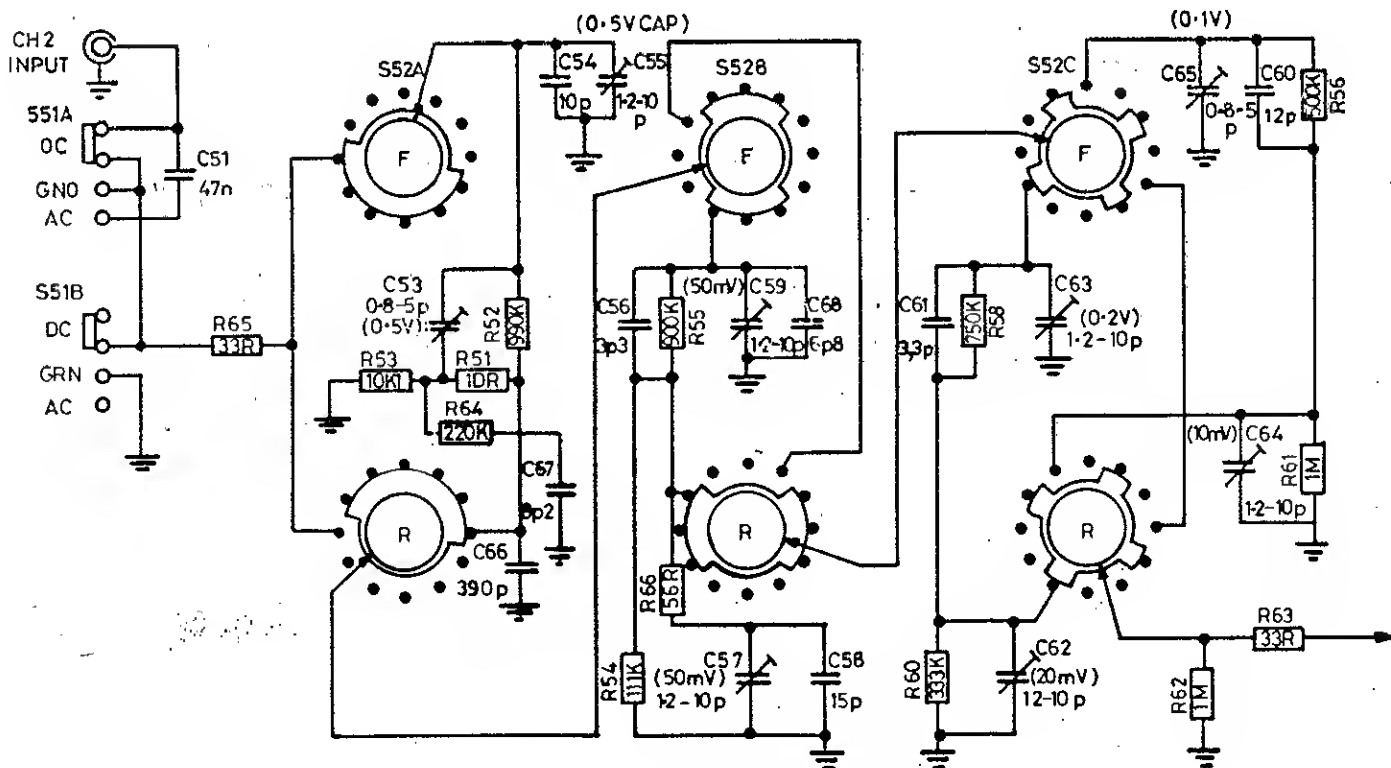
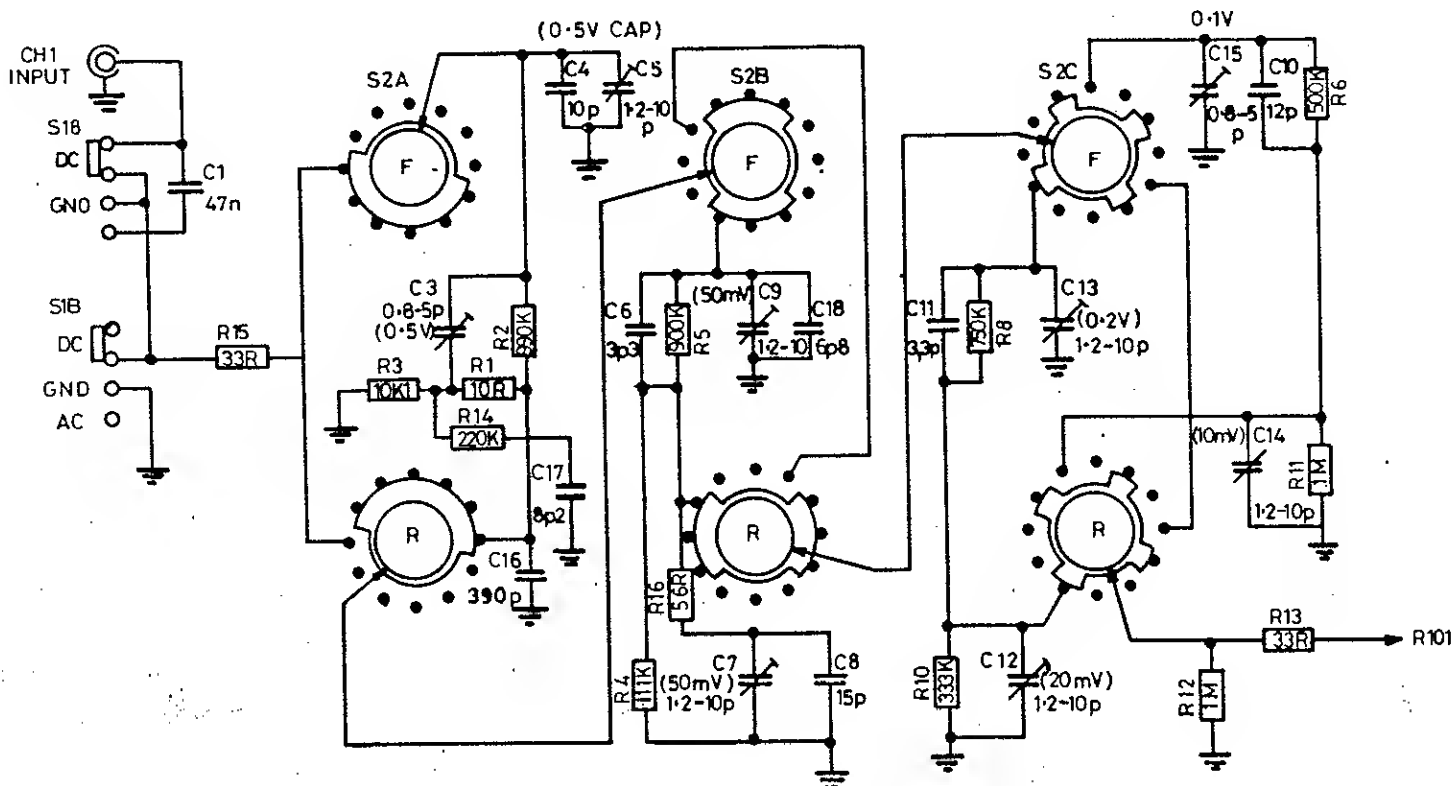
CCT REF	DESCRIPTION	MFR.	PART NO.
D301	IN4148 DIODE		
D302	IN4148 DIODE		
D303			
D304	IN4148 DIODE		
D305	IN4148 DIODE		
D306	IN4148 DIODE		
D307	IN4148 DIODE		
D308	IN4148 DIODE		
D309	IN4148 DIODE		
D310	IN4148 DIODE		
D401	IN4004 DIODE		
D402	IN4004 DIODE		
D403	IN4004 DIODE		
D404	IN4004 DIODE		
D405	IN4004 DIODE		
D406	IN4004 DIODE		
D407	IN4004 DIODE		
D408	GREEN LED	FAIR	FLV 340
D421	IN4004 DIODE		
D422	BY406 DIODE	PH	
D423	BY406 DIODE	PH	
D424	BY409 DIODE	PH	
D425	BY409 DIODE	PH	
D426	BY409 DIODE	PH	
D427	BY409 DIODE	PH	
D428	IN4148 DIODE		
D429	IN4148 DIODE		
D430	IN4148 DIODE		
D431	IN4148 DIODE		
D432	IN4148 DIODE		
<u>SWITCHES</u>			
S1	3 POS SLIDE SWITCH	NSF	SM2-3
S2	3 DECK ROTARY SWITCH (PXM)	AB	100-129
S51	3 POS SLIDE SWITCH	NSF	SM2-3
S52	3 DECK ROTARY SWITCH (PXM)	AB	100-129
S152	A & B A-C 3 SECTION ISOSTAT	SWANN	100-160
S201	2 POLE 5 POSITION ROTARY SWITCH	LORLIN	
S301A-D	4 SECTION ISOSTAT	BWD	

BWD B24 Parts List

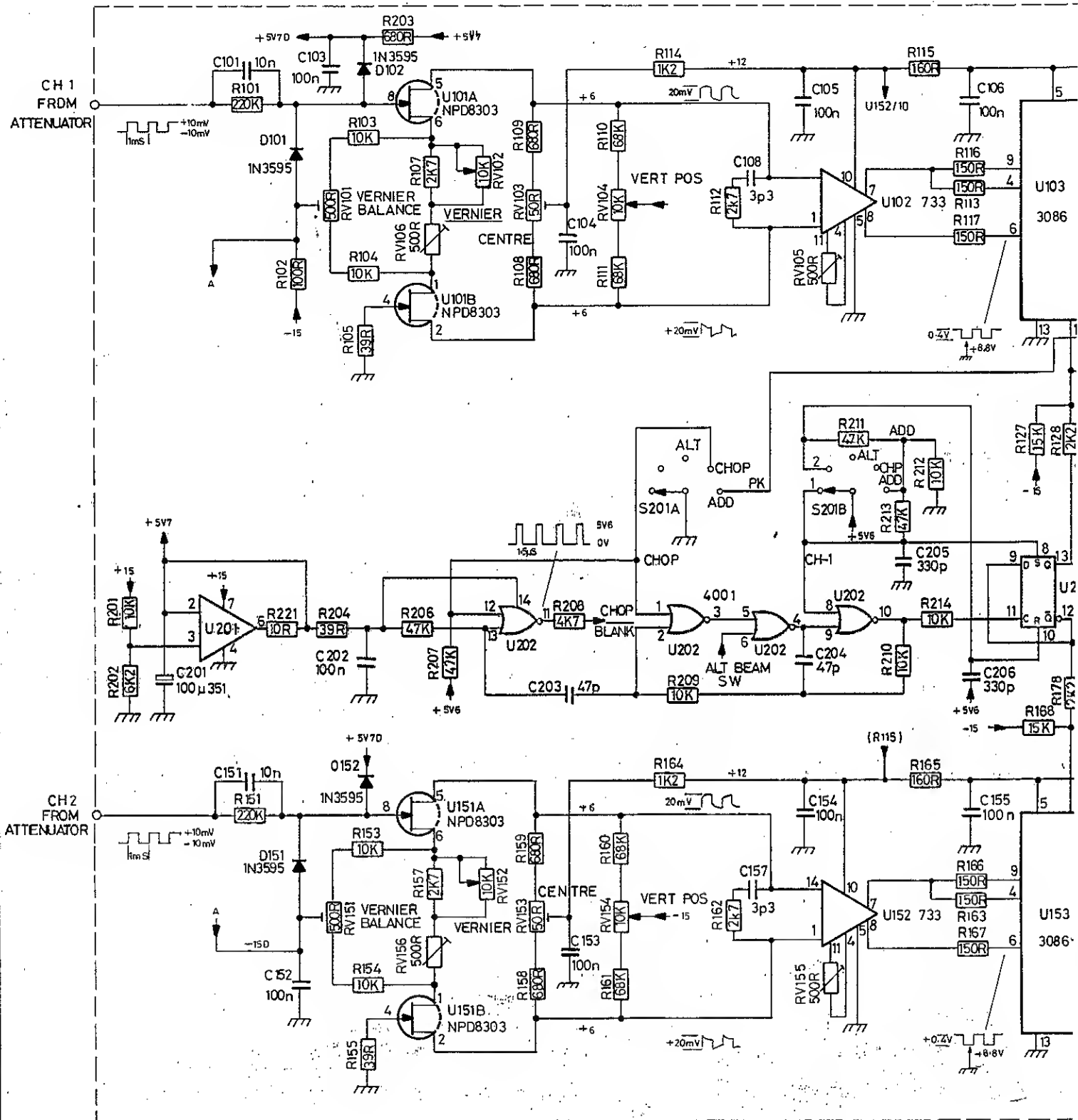
CCT REF	DESCRIPTION	MFR.	PART NO.
S302	DPST PUSH PULL SWITCH ON REAR OF RV301		
S303	DPST PUSH PULL SWITCH ON REAR OF RV304		
S371	2 DECK ROTARY SWITCH	BWD	100-150
S401	DPST ROTARY SWITCH ON REAR OF RV424		
	<u>MISCELLANEOUS</u>		
BRC	BEAM ROTATION COIL	BWD	090-217
T401	POWER TRANSFORMER	BWD	090-216
T421	CONVERTER TRANSFORMER	BWD	090-215
	CRT	MAT	140 CGB31
	CRT SOCKET	HOSIDEN	HPS 0051-01-010
	CRT SHIELD	BWD	1742A
	POWER CORD GREEN	PEASTON	1555A
	POWER CORD GRIP	UTILUX	H2097
F401	FUSE HOLDER	INTEL- ECSA	PF-7
F501	FUSE LINK 160MA 250V DELAY		5 x 20mm
	BNC SOCKETS		UG1094U
	4MM SOCKETS	MULTI- CON	EB4

BWD B24 Parts List

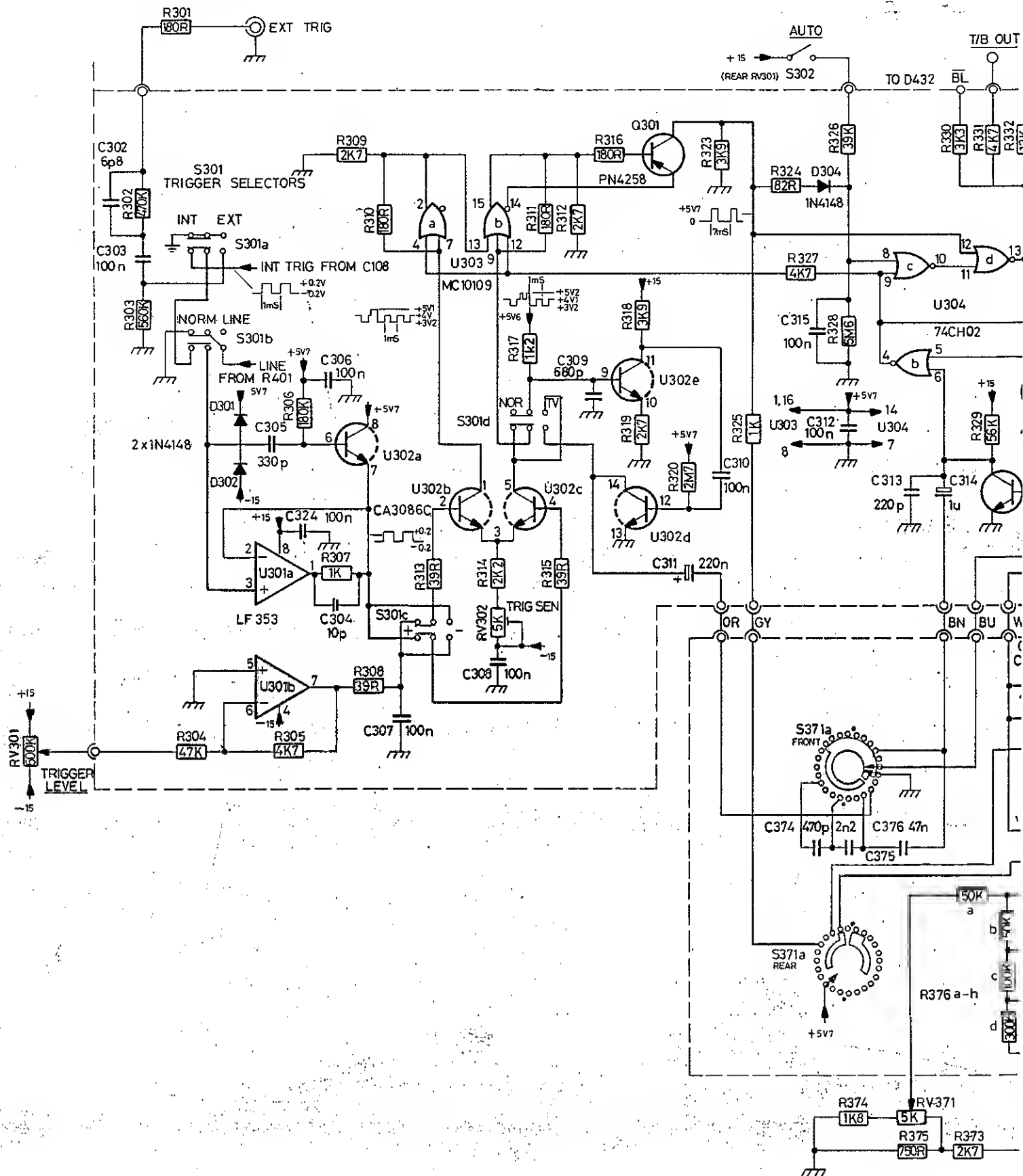
CT REF	DESCRIPTION	MFR.	PART NO.
	GRATICULE LIGHT BLUE		MULFORD NO. 310K
	ESCUTCHEON MOULDING	BWD	510A
	PUSH BUTTON KNOBS - CREAM	BWD	K10W
	PUSH BUTTON KNOBS - GREEN	BWD	K10G
	ATTENUATOR KNOB	BWD	K23W
	TIME BASE KNOB	BWD	K23W
	CHANNEL SELECTOR KNOB	BWD	K20W
	VERTICAL POSITION KNOB	BWD	K20W
	HOR. POSITION KNOB	BWD	K20W
	INTENSITY KNOB	BWD	K21W
	FOCUS KNOB	BWD	K21W
	TRIG LEVEL KNOB	BWD	K20W
	VERNIER KNOB	BWD	K20W
	HANDLE c/w END CLIPS	BWD	
	ALL OTHER ITEMS - ORDER BY DESCRIPTION		

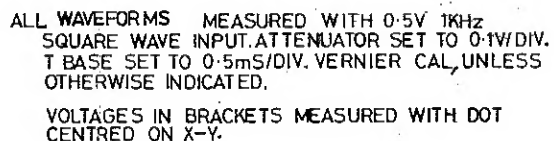


ISS	C/N	DATE	© COPYRIGHT 1981	BWD INSTRUMENTS	MELBOURNE AUSTRALIA
02	13/84	16-2-84	BWD INSTRUMENTS P/L	TITLE: CIRCUI	
			SCALE :	DIAGRAM	
			TOL. : 0.2mm unless specified.	824 ATTENUATORS	
			DRAWN JB	CHECKED JB	APP'D JB
					DRG. No: 1924
					SHT. OF

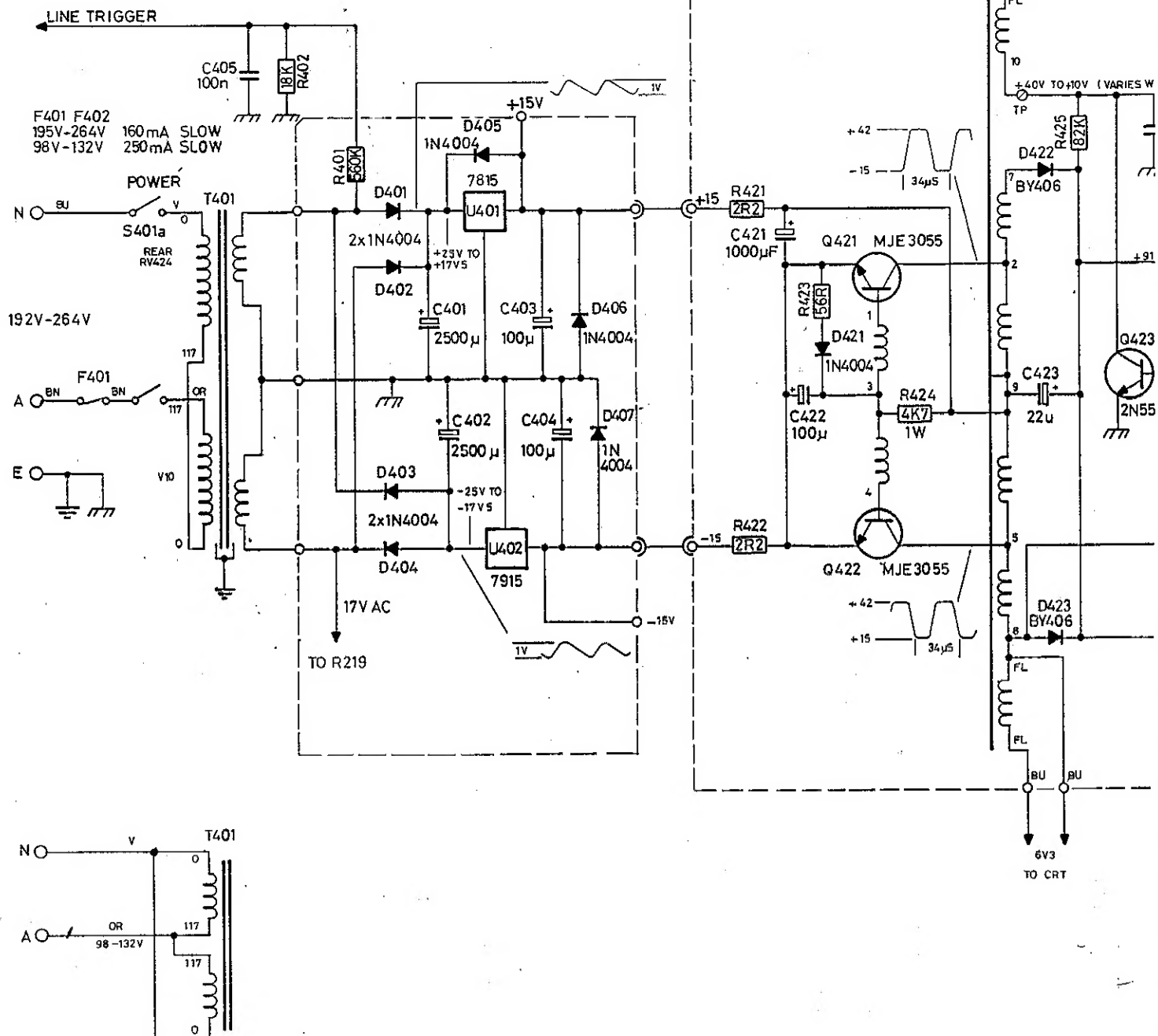


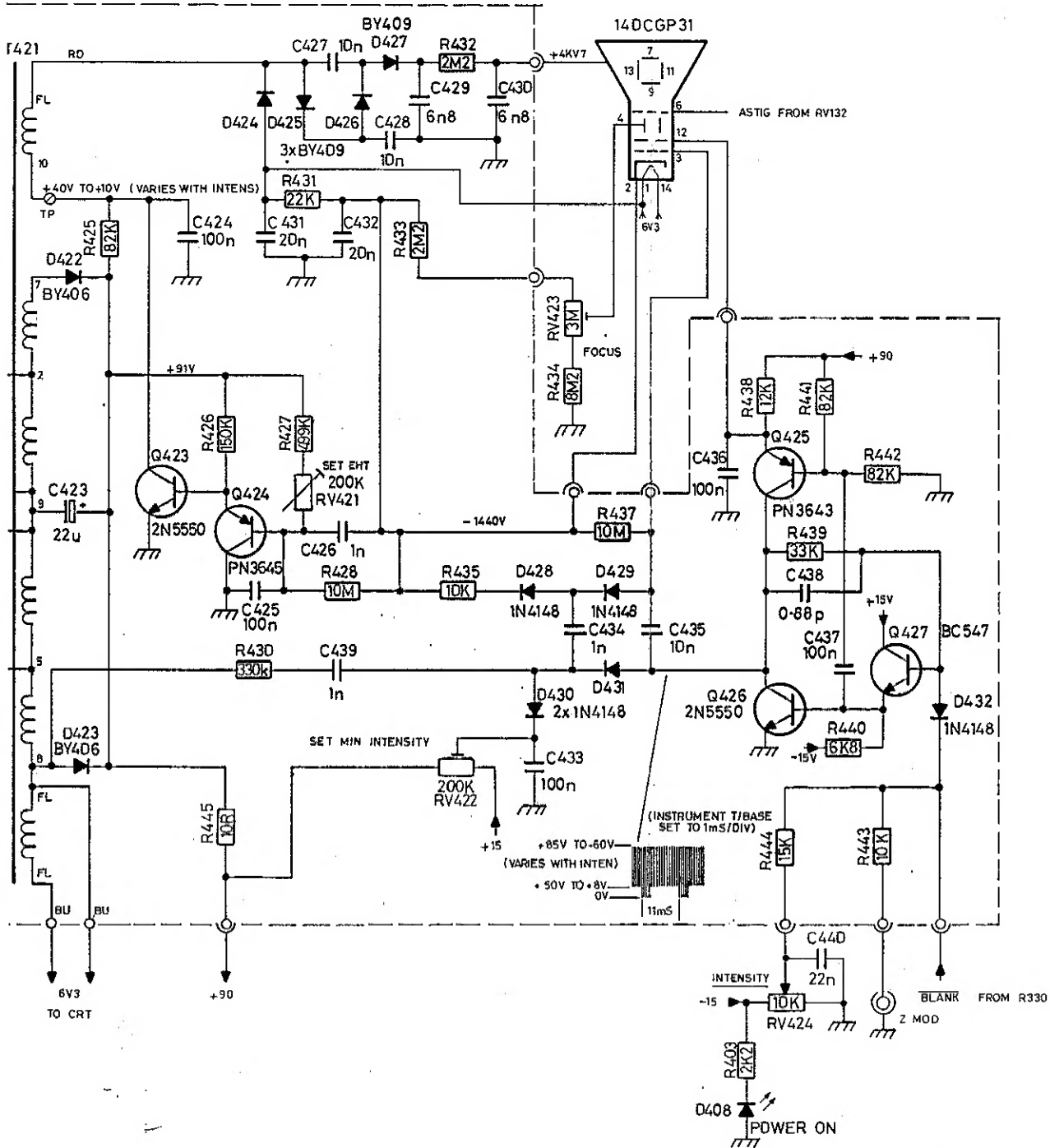
ALL WAVEFORMS MEASURED WITH 0.5V 1KHz
SQUARE WAVE INPUT. ATTENUATORS SET TO
0.1V/DIV T/BASE TO 0.5mS/DIV AND ALL
VERNIERS TO CAL.





ISS	C/N	DATE	© COPYRIGHT 1981			BWD INSTRUMENTS			MELBOURNE AUSTRALIA	
01		13.7.83	BWD INSTRUMENTS P/L			TITLE:				
02	43/84	15.8.84	SCALE :			CIRCUIT DIAGRAM T/BASE AND HORIZONTAL AMPLIFIER 824 OSCILLOSCOPE				
			TOL. ±0.2mm unless specified.			DRAWN	CHECKED	APP'D	DRG. No: 1926	
						JB			SHT. 1 OF 1	





ISS	C/N	DATE	© COPYRIGHT 1981	BWD INSTRUMENTS	MELBOURNE AUSTRALIA
01		13.7.83	BWD INSTRUMENTS P/L	TITLE: CIRCUIT DIAGRAM POWER SUPPLY 824 OSCILLOSCOPE	
			SCALE :		
			TOL. ±0.2mm unless specified.	DRAWN JES	CHECKED
				APP'D	DRG. No: 1927
					SHT. 1 OF 1

BWD INDUSTRIES LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 824

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
53720	1	19-1-84			

Issue	Sect.	Page	Cct.	A M E N D M E N T
1	9	4	1925	R216 was 560R now 510R 1% 1/4W MF
1	9	6	1927	R427 was 499K now 560K 5% 1/4W MF